POWER

Volume 56 New York, July 25, 1922 *Number* 4

Standardization

I SUPPOSE it would cut down the work of the world enormously if we would all wear the same kind of clothes, hats and shoes, and eat out of the same kind of dishes, and sit upon the same kind of chairs, etc.

What a chance for mass production! What a simplification of distribution! What a decrease in the cost of living—if it did not all get absorbed before it got to the ultimate consumer!

However, there are some things that we like to have some individuality about and in respect to which it is better that there should be some individuality, even if it does cost more.

But there are some people who are inclined to carry this matter of individuality to excess, especially when they are spending other people's money.

I knew a power-plant designer who had a supreme contempt for what he called the "catalog engineer." He would never buy anything ready-made if he could help it. No catalog size or style of engine would do. His cylinders must be meticulously proportioned for each particular job and his own ideas must be incorporated in the valve-gear and bearings. He would not use even a standard pipe fitting if he could find an excuse for designing one.

Of course, all of this cost money, and I doubt if it served its purpose enough better than standard apparatus and materials to justify the increased investment. It costs a whole lot less apiece to make a hundred engines from the same design and patterns than it would to make a single one. It costs only a few cents to turn out a standard fitting when the special tool is set and the stock running through it.

And the things made by standardized processes and to modern gages are of universal application. One has no longer to buy a bolt and a nut together to be sure that the nut will go on. The engineer of not so long ago had to carefully arrange or mark the nuts from the cylinder head so that each was identified with its own stud bolt, or he would find himself at the end of the circle with two or three that would not go back.

The man who knows how to use standard goods intelligently will get a better job at less cost than one who has to have things made to order or who uses adaptable, but less appropriate things from lack of knowledge of others that are especially suitable for the purpose.

The outfit of the operating engineer consists of "know-how" and mechanical proficiency, and no small item in his mental make-up is a knowledge of available apparatus, appliances, instruments, fittings and materials, their special qualities application, uses and limitations.

F. R. Low

Steel-Mill Power Plant of The Follansbee Brothers Company Toronto, Ohio

By Joseph Breslove*

POWER plant of 7,500-kw. capacity designed especially for steel mill service. Boiler plant contains six 6,000-sq. ft. boilers fired with underfeed stokers. Turbine-driven forced-draft fans installed in front of boilers. Circulating pumps are in a separate building, and are primed and started from the turbine room.

THERE has recently been placed in operation by the Follansbee Brothers Co., at Toronto, Ohio, a new sheet mill with an annual capacity of 60,000 tons of high-grade hammered open-hearth steel sheets. This plant comprises an entirely new development and embraces the most modern practice in the production of high-grade sheets. It is designed to take care of all operations from the production of the open-hearth steel down to the finished material. The new mill supplements the company's older mill of the same capacity at Follansbee, W. Va. It is electrically driven throughout, power being supplied by a steam-turbine power-station adjoining the plant. This power station was designed and constructed for steel-mill service, is adjacent to the Ohio River and on the Pittsburgh & Cleveland R.R.

*Consulting engineer, Pittsburgh, Pa.

An abundant supply of condensing water is available, and coal will be furnished by the company's own mine adjoining the property, but in case of emergency foreign coal can be received by main-line railroad.

The electrical equipment comprises two 1,500-hp. induction motors, one for each group of sheet mills. The motor is geared to the drive through an inclosed cut herringbone gear unit with flywheels on the high-speed shaft. A 5,000-hp. reversing mill motor drives the 30-in. bar mill. This motor operates on 600-volt direct current and has a speed of 0-100 r.p.m. in either direction. Direct current is supplied to the reversing motor through a suitable flywheel motor-generator set and slip regulator. In addition there are the usual smaller motors, motor-generator sets, transformers, etc. In the design of the power house the particular

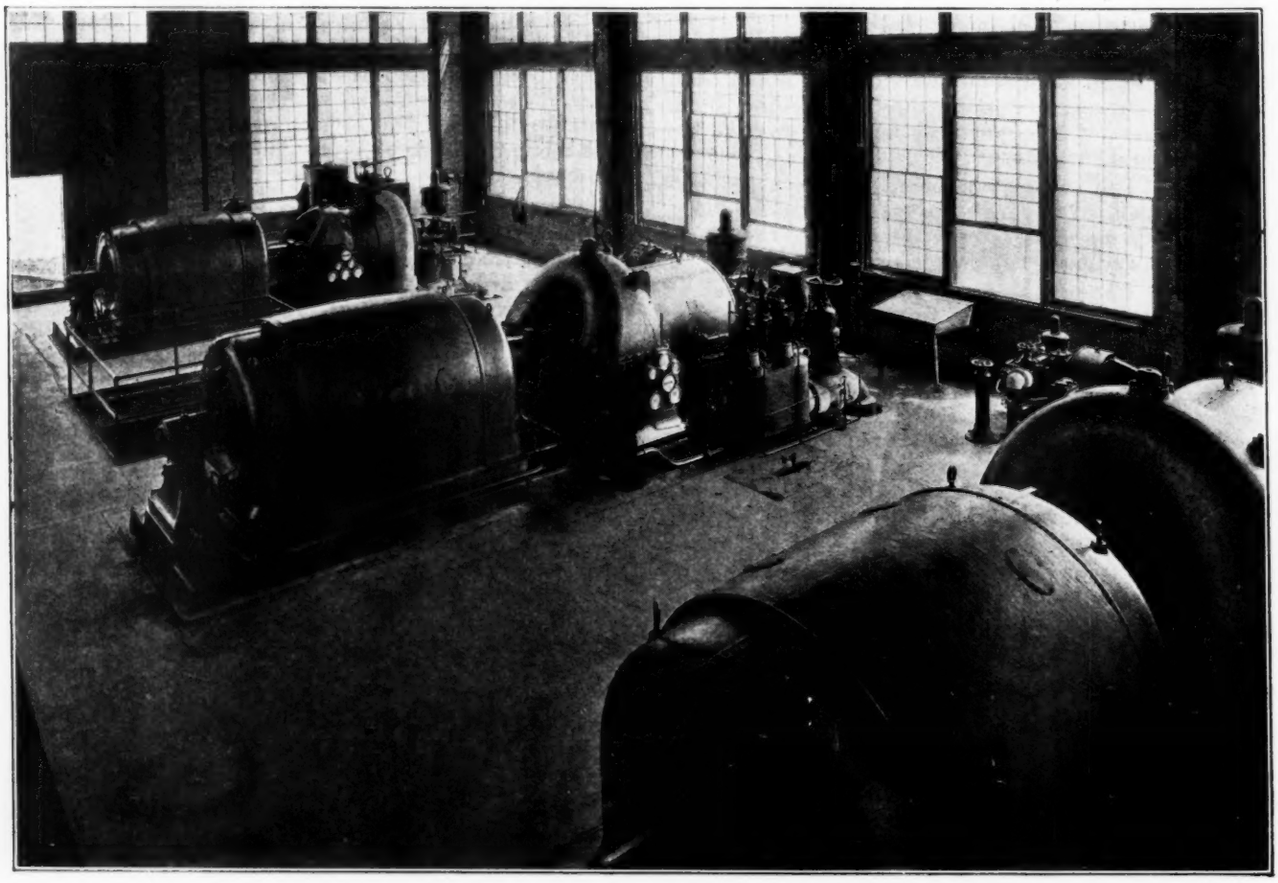


FIG. 1. TURBINE ROOM CONTAINING ONE 1,500-KW. AND TWO 3,000-KW. UNITS

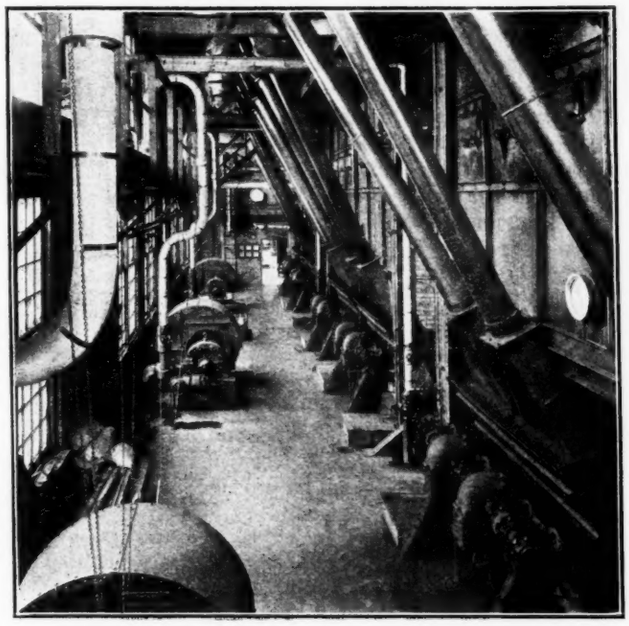


FIG. 2. BOILER-ROOM FIRING AISLE

features governing steel-mill service were kept in mind, and a few comments on this service may be in order:

The steel-mill power plant must be considered in a somewhat different light from that of the public-service corporation plant and more in its relation to the mill that it is to serve. Reliability is the most important factor for both of them, but in the case of the public-service plant the only source of income is the sale of power and, therefore, economy of operation and maintenance is the factor that will determine whether the plant is run at a profit or loss. While economy is also of great importance in the steel-mill plant, the revenue is not from the sale of power and the power plant is only incidental to the operation. In the design of the plant the engineer is prone to be carried away by enthusiam for labor- and fuel-saving devices with the result that the completed plant is not as simple as it should be for the particular conditions. In the determination of steam pressure, vacuum, desirability of economizers, etc., this should be held in view, also the ratings at which the boilers are to be operated. There is no doubt that where fuel is comparatively high the economizer is a profitable investment, but this is not necessarily the case where fuel is less expensive and plant simplicity of first consideration. It should be composed of the simplest elements consistent with a fair degree of economy, and the design should be such that its operation is within the scope of the average engineer and reliability is not sacrificed for economy alone. It is most desirable to avoid extremes in design. A shutdown of only one day in the mill will soon offset all the gain derived from highly specialized apparatus for coal saving.

Boiler-Room Equipment

The boiler room contains six 6,000-sq.ft. water-tube boilers with superheaters designed for operation at 200 lb. steam pressure and 100 deg. superheat. Each boiler is fired by a six-retort underfeed stoker and is provided with mechanical soot blowers, feed-water regulators, steam-flow meter and draft gages. Under normal conditions they will operate at approximately 175 per cent of rating. The boilers are set two in a battery, forming three batteries, each of which is connected to an independent brick stack 8 ft. in diameter and 175 ft. in height, allowing for a short steel-plate breeching directly into the stack. Owing to the large quantities of steam required for the forging press, gas producers, mill heating and heating of the company's houses, the ratio of installed boiler capacity to electric generating capacity is higher than would obtain in the ordinary public-service station.

Three turbine-driven draft fans, one for each battery, are located in front of the boilers on the boiler-room floor and furnish air for the stokers. Each fan has a maximum capacity of 44,000 cu.ft. per min. against a static pressure of 7 in. of water at a speed of 1,600 r.p.m., which is sufficient for two boilers at 250 per cent rating. At 4-in. water pressure the fan will deliver the same amount of air at 1,373 r.p.m. Each fan discharges through a Y-connection into a common concrete air duct running the full length of the boiler house. The air duct is sectioned off by gates between batteries so that any battery of boilers with its corresponding fan may become a separate and distinct unit or the fan may be shut off entirely through a special gate in the outlet and the boilers continue to be supplied with air from the main air duct. Under normal operation two fan units are sufficient to carry the entire load, leaving one unit as a spare. Each pair of stokers is driven by a vertical engine cross-connected through a countershaft underneath the floor so that any engine may drive any stoker. It will be seen that two boilers, one stack, one fan and the stoker engine form a convenient operating unit, but that operation is not limited to the unit form. The installation of these fans on the boiler-room floor permits of greater accessibility, and their closer proximity to the operator insures attention, cleanliness and less liability to shutdowns.

The boiler room, stokers and draft fans are shown in

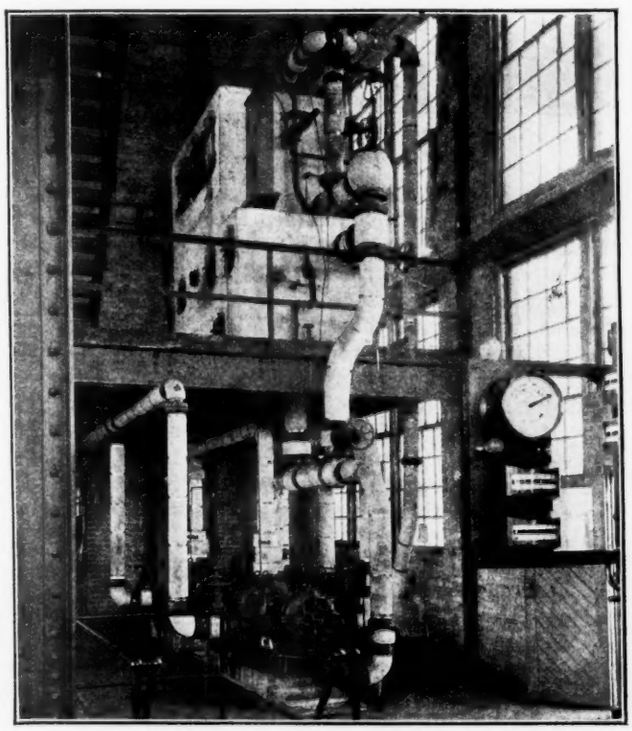


FIG. 3. ARRANGEMENT OF FEED-WATER PUMP AND HEATER

Fig. 2. The boilers are installed with the lower drum 7 ft. above the boiler-room floor, resulting in a furnace volume of 1,250 cu.ft. and a ratio of 0.20 cu.ft. per square foot of water-heating surface. The rear part of the boiler-room floor between the bridge wall and building wall is dropped down 2 ft. 6 in. below the main floor, permitting a man to use the observation door in the bridge wall without discomfort. The front boiler columns are incorporated in the building steelwork, resulting in an unobstructed firing aisle.

Coal and Ash Handling

The main source of coal supply for the plant will be the company's mine adjacent to the mill. The coal will be crushed and weighed at the tipple and transported about 1,000 ft. across the public road and street-car tracks on an elevated belt conveyor directly to the

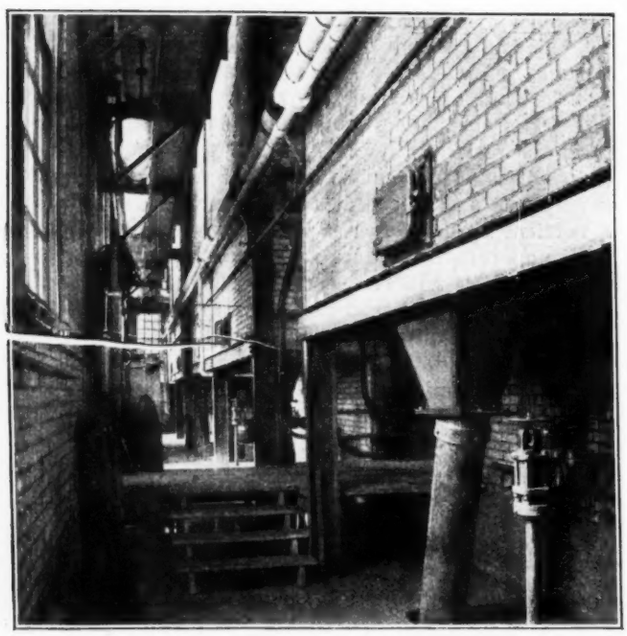


FIG. 4. REAR OF BOILERS

overhead storage bin in the power house. When buying foreign coal, it will be received at the power house on a railroad siding close to the boiler room, discharged into a track hopper, crushed to stoker size and elevated by a bucket elevator to the belt conveyor over the coal bunker, which runs the full length of the boiler room. It is distributed throughout the bunker by an automatic self-propelling tripper. The capacity of the coal bunker is three tons per running foot, or a total capacity of 300 tons, which is sufficient for about forty to forty-eight hours' run. The bunker is of steel-plate construction, parabolic type. Coal is distributed to the stoker hoppers through swinging gates and individual chutes.

Underneath each boiler is an ash hopper of 275 cu.ft. capacity with a cast-iron rack and pinion-type gate, having two openings, each 30 x 36 in. Each hopper has sufficient storage capacity for an eight-hour run. From the hopper ash is dumped into side-dump steel cars running on a track in a tunnel carried under the entire length of the boiler room. At one end of the tunnel is an automatic skip hoist into which the ash cars are dumped and elevated to an ash bunker outside the power house. The ash bunker is arranged so that ashes may be taken away in railroad cars or by truck. The ash tunnel has a clear width of 11 ft. 6 in. and a height of 6 ft. 9 in., allowing for a clearance of 6 ft. to the lowest point of the gates. Each boiler is furnished with a dust chute, passing down through the boiler-room floor and discharging into cars in a similar tunnel alongside the ash tunnel. These cars can be switched into the main tunnel and discharged into the ash bunker through the skip hoist.

Electric Generating Apparatus

The electric generating equipment consists of three high-pressure condensing steam-turbine units delivering three-phase 60-cycle current at 2,300 volts. Two of the units are rated at 3,000 kw. at 80 per cent power factor and one at 1,500 kw. at 80 per cent power factor. The turbines have a special overload nozzle so that 25 per cent greater load can be carried at 100 per cent power factor or a corresponding overload with any power factor over 80 per cent. The two larger units are sufficient to take care of the entire mill load, and the smaller unit will be operated only during periods of light load or when the mill is shut down. In the event that one of the larger machines should suffer an accident, the remaining 3,000-kw. and 1,500-kw. units will be able to carry the mill load by operating at some overload. This really allows one of the three units to be carried as a spare. Excitation will be taken care of by two independent exciter units, one of which is a motor-generator set and the other driven by a non-condensing steam turbine. One unit is large enough for all purposes, and ordinarily the motor-driven set will be in operation. Cooling air for the turbo-generators is taken from outdoors through individual sheet-metal ducts.

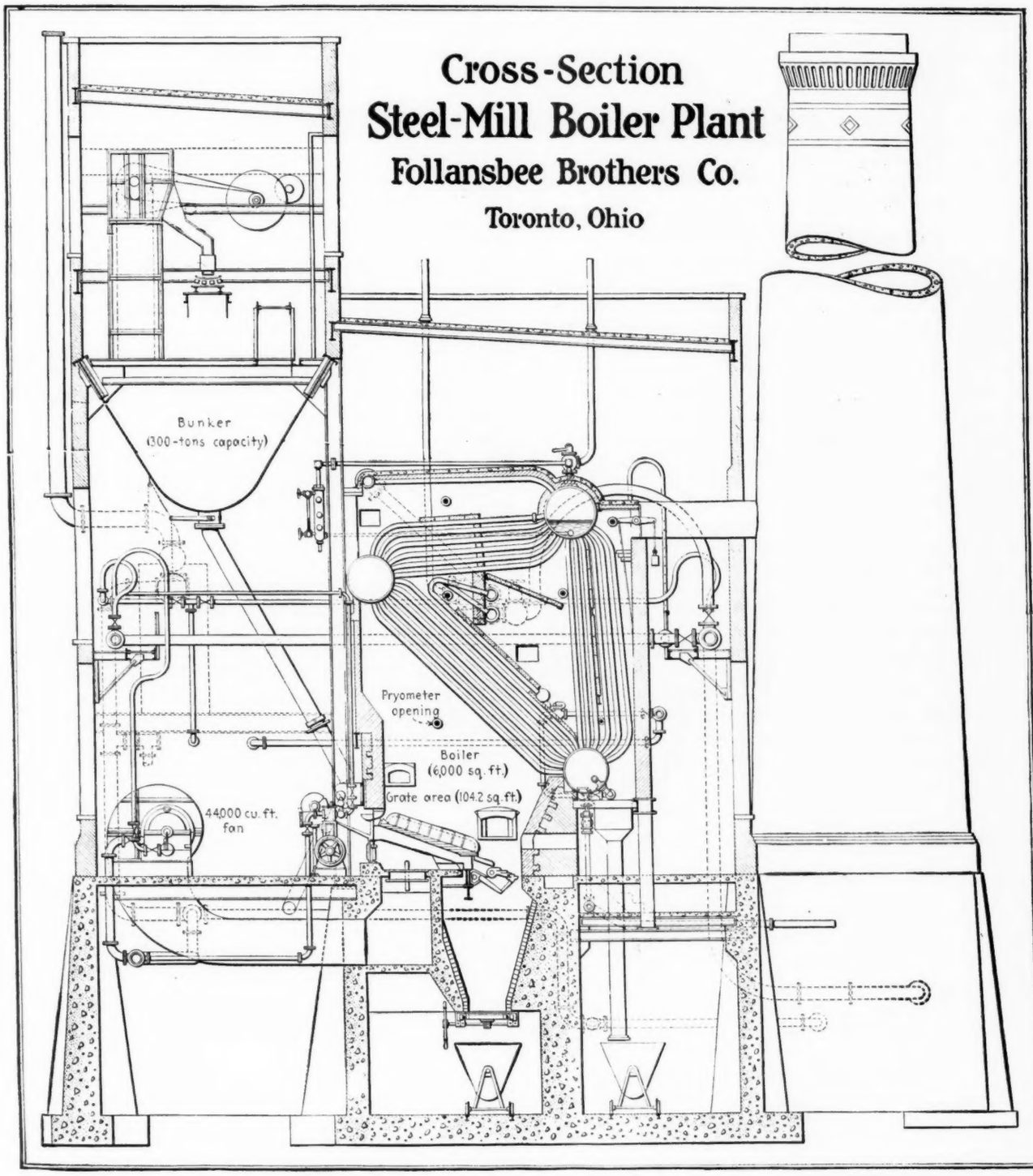
The 2,300-volt alternating-current power lines are carried from the generators to the switchboard on one side of the turbine room, through the oil switches to an upper floor in the power house, where are located the choke coils, lightning arresters and disconnecting switches. From here they are taken across to the mill on a steel bridge spanning the railroad tracks. This bridge also carries the steam supply line to the mill. The generator field rheostats are on a mezzanine floor below the switchboard and chain connected. The service transformers are also installed on this mezzanine floor.

The oil-filtering system of the power house has an especially large settling or receiving tank in the turbine-room basement. This allows either of the steam-turbine units to be drained completely of oil when necessary, without wastage. From the settling tank it is pumped to the filter and from there to an overhead storage tank from which it flows to the turbines by gravity.

Details of Condenser Equipment

The main turbines are served by surface condensers, the 3,000-kw. units having 5,000 sq.ft. of cooling surface, and the 1,500-kw. unit 2,500 sq.ft. The turbine- and boiler-room floors are two feet above high-water level, necessitating a 23-ft. basement for the desired elevation of the condensers with reference to economical pumping of the circulating water. The normal river level is 38 ft. below the turbine-room floor, as the river at this point has an extreme range of over 40 ft. The condensers are installed underneath the turbines and suspended from special cast-iron connections

which in turn are supported on I-beams cast into the foundations just below the turbine expansion joint. This allows unrestricted expansion of the condenser and exhaust connection without imposing any strains on the turbine exhaust expansion joint other than that due to temperature changes in the turbine itself.



The circulating-water connections to the condenser shell are made through special reinforced rubber expansion joints. The water outlet on the condenser is 23 ft. above the average river level, and the elevation of the condenser is therefore such as to take advantage of the siphon head, resulting in a minimum lift for the circulating pumps. The discharge line is, of course, submerged below the lowest river level.

Circulating water is supplied by motor-driven centrifugal pumps installed in the river pumphouse about 200 ft. from the power house. The pumphouse is a monolithic concrete structure built in the river with an entrance above the highest water level. A strainer is installed in the suction line of each pump, and the inlet to the pumps is in a forebay of the pumphouse, which is furnished with removable trash racks. The pumps are controlled by automatic starters operated from push-button stations conveniently located at each

condenser in the power-house basement, or they may be operated from the pumphouse itself. Each condenser is served by its own pump, but the piping is so interconnected that any pump may be used in an emergency. Each centrifugal pump supplies its 5,000-sq.ft. surface condenser through an independent 16-in. line with a 16-in. return line to the river. The pump serving the 2,500-sq.ft. surface condenser discharges through a separate 12-in. line, but the return line from this condenser discharges to the river through either of the 16-in. return lines serving the larger condensers. Inasmuch as the smaller turbine will be in operation only infrequently, it was not thought desirable to go to the expense of an independent return line. The two 16-in. return lines are, however, of sufficient capacity to accommodate all three condensers in an emergency.

Pumps Primed from Power House

The pumps in the pumphouse may be primed from the power house, making it unnecessary for the operator to go to the pumphouse. Suitable gages at the condenser indicate when the pumps are primed, and they can then be started through the aforementioned push-button stations. The condenser vacuum pumps are of the steam ejector type and in duplicate, one ejector having sufficient capacity to take care of its respective condenser, the other being in reserve. In order to reclaim the steam used in the ejectors, they are exhausted into a small 200-sq.ft. auxiliary surface condenser. The entrained air is separated and allowed to go free to the atmosphere. Each main condenser is served by a turbine-driven condensate pump, the condensate being discharged to the heater. On its way to the heater, however, it is pumped through the small auxiliary condenser, where it acts as circulating water for condensing the air ejector steam. The condensate from the auxiliary condenser, which is comparatively small in quantity, is handled by a motor-driven rotary pump which also discharges into the heater. The piping is so arranged that when desirable the main condensate can be pumped directly to the heater and bypass the auxiliary condenser. Should it be necessary to shut down the auxiliary condenser or its condensate pump, provision has been made to allow the air ejectors to discharge directly to atmosphere through a bypass line from each ejector.

For non-condensing operation each turbine exhausts through its respective atmospheric relief valve to atmosphere through an individual exhaust line.

An opening in the turbine-room floor permits the overhead crane to handle machinery installed in the basement. It is large enough to allow for removal of the largest piece in the basement.

Boiler-Feed Water

The main supply of boiler-feed water is obtained from the condensate of the turbines and heated in an open feed-water heater capable of heating 120,000 lb. of water per hour from an initial temperature of 40 deg. F. to within two degrees of the exhaust-steam temperature. The heater is installed on the mezzanine floor in the turbine room, allowing for a short and direct connection to the two turbine-driven boiler-feed pumps on the main floor below the heater. It is furnished with a V-notch meter of the indicating and recording type. The location and arrangement of heater and boiler-feed pumps allows of cleanliness of operation and ease of supervision and also permits of the necessary hydraulic head over the pumps for handling the hottest water. This is shown in Fig. 3. River water is used as makeup. It is taken from the circulating-water discharge of the main condensers. This water is also used to supplement well water in the mill. Sufficient steam-driven auxiliaries will be operated to provide the proper heat balance for the station.

Piping Layout

Particular pains were taken to lay out the steam and water piping so that it could be easily handled and would require a minimum of attention. Long-radius bends and welded joints are much in evidence. Wherever possible extra fittings in the high-pressure lines have been avoided and welded necks substituted. The geographical conditions of the property necessitated placing both the turbine and boiler rooms in one line, so that a loop header around the turbine and boiler rooms was not feasible. Each boiler discharges through a non-return valve and long-radius bend to a

PRINCIPAL EQUIPMENT IN THE POWER HOUSE OF THE FOLLANSBEE BROTHERS COMPANY AT TORONTO, OHIO.

BOILERS	
Type	Water Tube-Badenhausen
Number	6
Water-heating surface, sq. ft	6,000
Working pressure, lb. gage	200
Superheat, deg. F.	100
Grate area, per boiler, sq. ft	104.2
Ratio water-heating surface to grate surface	57
Furnace volume per boiler, cu.ft	1 250
Ratio furnace volume to grate surface	12

STOKERS	
Make	Westinghouse Underfeed
Number of retorts, each	6
Drive	American Blower Engines

FANS	
Sturtevant—Capacity 44,000 cu.ft. per min. against 7 in. water pressure	
Number	3
Drive	Terry Steam Turbine

STACK	
Brick, Kellogg	One per two boilers
Height, ft	175
Diameter at top, ft	8

COAL HANDLING	
Overhead bin, suspended steel	
Capacity	300 tons
Bucket elevator, 4 roll crusher and belt conveyor with tripper	Heyl & Patterson
Coal chutes and gates	Heyl & Patterson

ASH HANDLING	
Ash gates	Baker-Dunbar-Allen
Opening for each ash hopper	2—30 in. x 36 in.
Skip hoist	Heyl & Patterson

TURBINE UNITS	
Make	Westinghouse Elec. & Mfg. Co.
Capacity at 80 per cent power factor	2—3,000 kw. 1—1,500 kw.
Type of generator	3-phase, 60-cycle, 2,300-volt
Switchboard	General Electric Co.

CONDENSERS	
Make	Westinghouse Elec. Mfg. Co.
Type	Surface
Air removal	Westinghouse air ejectors
3 Condensate pumps	Westinghouse turbine-driven
3 Circulating pumps	Allis-Chalmers motor driven

BOILER FEED	
2 Boiler-feed pumps—Cameron Centrifugal pumps connected to Kerr steam turbines	
1 Feed-water heater	Warren-Webster & Co.
Feed-water measurement	Lea V notch, indicating and recording meter

MISCELLANEOUS EQUIPMENT	
Steam and water piping	National Valve & Mfg. Co.
Power-house crane	Milwaukee Electric Crane Co.
Soot blowers, Diamond	Power Specialty Co.
Feed-water regulators, Copes	Northern Equipment Co.
Draft gages	Precision Instrument Co.
Steam-flow meters	Republic Flow Meters Co.
Vacuum gages	Taylor Instrument Co.
Blow-off valves	Cadman Mfg. Co.
Non-return valves	Ruggles-Klingemann Mfg.Co.
Pressure regulators	Ruggles-Klingemann Mfg.Co.
Oiling system	S. F. Bowser Co.

10-in. header at the rear of the boilers. This header runs the entire length of the boiler room, passes through the turbine-room wall and drops down through the turbine-room floor into the basement, where it runs the entire length of the turbine room.

All connections to the turbines and turbine-room auxiliaries are made through long-radius bends and up through the floor so that there are no overhead steam pipes. The condenser auxiliaries in the basement are supplied from this same header. In the boiler room there is an auxiliary loop steam header which is tapped into the main header at each end of the boiler room and passes around it just above the draft fans. All the boiler-room auxiliaries, such as draft fans, stoker engines and boiler-feed pumps, are taken off this loop. The steam-supply line to the mill is also taken off this auxiliary loop. Both the main steam header and the auxiliary header are sectionalized through cutoff valves so that steam can be carried on the auxiliaries as long as one battery of boilers is in operation. In addition there is an auxiliary connection from the main header to the boiler-feed pumps so that if the loop should fail the boiler-feed pumps will still receive steam. All the high-pressure valves have cast-steel bodies and monel fittings. The piping is extra heavy with rolled steel Vanstone joints. Both the main and auxiliary headers in the boiler and turbine rooms are furnished with galleries so that all valves are accessible.

All auxiliaries exhaust into a common exhaust line in the basement, which passes up through the turbine-room floor to the heater. The water lines to and from the surface condensers pass through the power-house walls under the basement floor and directly to the condenser openings.

The piping is so arranged that practically all overhead lines have at leats six feet clearance to the floor and there are practically no pipes on the floor or at such an elevation as to be in the way of the operator.

Saturated vs. Superheated Steam for Oil Pumping

By W. G. Stubbs*

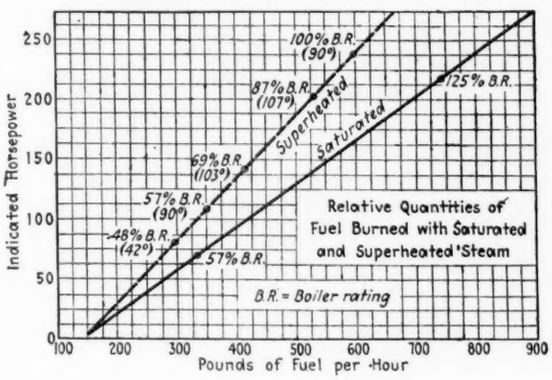
The following facts and figures are the results of tests made at a crude-oil pumping station of the Associated Pipe Line Company in California. A series of tests were made using saturated steam, and then superheaters were installed and a like series run using superheated steam. In speaking of tests and in comparing the results, it must be understood that no special effort was made to have everything primed and set and carried out under ideal conditions, but that the idea was to take accurate data under the ordinary every-day operation of the plant. As the plant equipment is always kept in good condition, as regards both the engine and boilers, it was necessary only to set up the weigh scales for the oil fuel and water and the separating calorimeter, the plant having a CO_2 and draft recorder and a recording pyrometer for the stack temperature. The boiler is a 2,500-sq.ft. water-tube having a single horizontal gas pass with the lower tile placed on the tubes the third row up. Firing is done with mechanical burners of the Coen system and a rotary air admission through their type L. R. register. Oil of 14.5 gravity Baumé was burned at a temperature of 250 deg. F.

*Engineer of Tests, Associated Pipe Line Company, California.

The main pumping engine is a Jeanesville compound non-condensing unit 22 x 38 x 9½ x 36 in. of the duplex, direct-acting plunger type, operating at a constant load throughout each test. The tests were all of six hours' duration, and the method on each occasion was simply to set the weigh tanks and water-column gage marks and at a single, start; in other words, collect the data as the plant was operating.

Indicator diagrams were taken every thirty minutes, and all of them worked out to obtain the quantity of steam used. In compiling the results of the fuel used per indicated horsepower, all of it in each case is charged against the main engine, as the same auxiliaries were operated during each test and doing a like amount of work, so that no data on the auxiliaries were considered necessary.

In the chart the dotted line shows the saving in fuel by the use of superheat. Although it is true that if the over-all boiler and furnace efficiency were high or low on the different tests, the fuel per indicated



horsepower would be more or less, the result showed that very nearly the same efficiency was attained at the boiler, namely, 76 per cent.

Variation in the superheat indicated by the points on the curve was attained by varying the tile baffling, changes being made to ascertain what would be necessary for any degree of superheat that should be decided on in future installations, as the present installation was our first with the superheater in the furnace. The

COMPARATIVE RESULTS WITH SATURATED AND SUPERHEATED STEAM

	I. Hp.	Steam, Lb. per I. Hp. Hr.	Fuel, Lb. per Hr.	Efficiency Boiler, Furnace and Superheater	Boiler Rating per Cent
Saturated steam.....	222	30.6	738	76.2	124
Superheated steam, 107 deg. at throttle.....	205	24.3	530	76.2	89

header of the superheater was inclosed in a cast-iron casing in the back wall, and the heater elements projected into the furnace, the front ends being protected by a firebrick baffle.

From the superheater to the main engine throttle, the distance is 130 ft. It was found that the drop in temperature was from 15 to 33 deg., depending on the velocity of the steam through the line.

Taking one case as an example to compare the use of saturated versus superheated steam, the accompanying table contains some interesting results. While it is true the cases are not quite parallel regarding the indicated horsepower, the idea is to show the possibilities in economy and fuel saving, as shown by the pounds of fuel per hour and the lowering of the boiler rating.

Foreign Gas in the Refrigerating System

By T. M. Gunn

ONE of the several obstacles that must be overcome to secure good results in the ammonia-compression system of refrigeration is the presence of air and foreign gases. When these accumulate, the results are seen in the high-pressure part of the system, usually in the increase of condenser pressure. In extreme cases the condenser has so far failed to function that only part of the time does liquid ammonia reach the expansion valve, and the refrigerating effect of the coils is largely lost.

Foreign gases in the condenser have a tendency, for reasons that will be explained, to gather on the cooling surface and keep away the ammonia that should have free access to the surface, so as to be cooled and condensed.

The presence of air may be the result of a leakage into the system at a time when a vacuum was formed in one part or another, or the air may have remained from the time when the system was filled with ammonia. When repairs are to be made, the part of the system to be repaired is pumped to a vacuum to remove the ammonia before it is opened. In a similar way the air in this part is exhausted before ammonia is admitted. A perfect vacuum is impossible, and this process always admits some air to the system, though it may be only a small amount if care is exercised and the vacuum is good.

When cleaning the condenser or expansion coils of oil by blowing out with steam and air, another opportunity occurs for the admission of air. Other methods of cleaning are often used, involving the maintenance of a vacuum for some time. Every time a vacuum is formed in a part of the system, there is danger of air leakage into the system, especially by way of the compressor stuffing box.

ENGINEERS are more or less familiar with the problem of foreign gases in the refrigerating plant. This article discusses the reason for these gases, the point of accumulation and the proper method of freeing the system. Attention is called to the high ammonia loss which occurs when purging is resorted to on frequent occasions.

In low-temperature refrigeration it is sometimes necessary to operate with a vacuum constantly on the coils. Compressors designed for this purpose have stuffing boxes so arranged that there is always an outward pressure, thereby preventing the inward leakage. But it often happens that compressors intended for use on back pressures above atmosphere are made to work on a vacuum. This may happen when the evaporating coils are clogged or heavily coated with oil and tar, when the expansion valve is choked, or when there is too little ammonia in the system. Whatever the cause, a vacuum maintained on a machine not designed for that condition results in air leakage.

Other gases than air are found in the ammonia system, in small or large quantities. Ammonia as purchased is not pure. When it contains many impurities, it leads to various troubles. Tarry deposits may separate and collect in the pipes. Other impurities decompose into various gases, especially under the action of heat.

Another possible source of foreign gases exists when unsuitable lubricants are used. Some of these distill from the hot parts of the compressor, and these vapors may break down into permanent gases. Parts of some compounded oils decompose with similar results.

Permitting the compressor to run unnecessarily hot increases the formation of these gases and at the same time decreases the useful work of the compressor, so the regulation of this temperature by means of the expansion valve should be carefully watched. The suction should be frosted almost to the compressor; that is, the temperature of the suction gas should be very little above that at which the liquid evaporates in the coils; this avoids danger of getting slugs of liquid in the compressor and

still keeps the compressor temperature moderate, minimizing the formation of gases.

A knowledge of the causes, just enumerated, of the presence of foreign gases in the ammonia system enables the operating engineer to do much toward their avoidance. There are, indeed, plants in which the accumulation of such gases is scarcely noticeable. On the other hand, in a great number of plants their presence forms a serious cause of inefficiency.

These gases accumulate in the high-pressure part of the ammonia system. This is because they are pumped

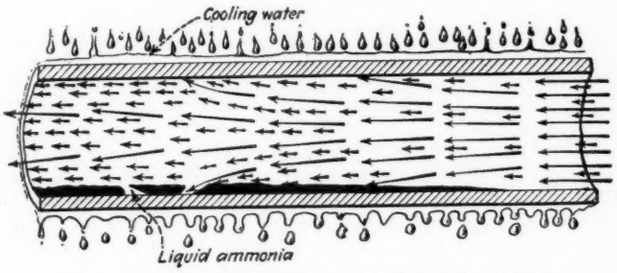


FIG. 1. CONDENSATION OF AMMONIA VAPOR

from the low pressure to the high by the compressor, and they are unable to return through the expansion valve, which is constantly flooded by liquid ammonia. In order to explain their damaging effect on efficiency and to ascertain how they can be best removed, it is desirable to trace in detail the movements of the ammonia and the foreign gases in the condenser.

The common statement is that the air and other gases collect at the highest part of the ammonia system. But the writer has been repeatedly asked: Why should air rise to the top when it is about 50 per cent heavier than ammonia gas? Is the common understanding wrong? If not, why? This seems to be a point not understood by many, and in fact this misunderstanding in numerous cases is responsible for many mistaken arrangements for purging gases from the system.

As to the physical principles involved, the first observation is regarding gas and vapor mixtures. So long as the vapor is above its condensing temperature, it acts as a gas. Two gases, one heavier than the other, when once mixed together cannot be separated by gravity. If it were not for this law, the human race could not live, as carbon dioxide, one of the heavier constituents of the atmosphere, would settle to the surface of the earth and suffocate every living being.

When two gases, or a gas and a vapor, are mixed, each occupies the entire volume of the container, and the two have the same temperature, but each exerts its own pressure, just as if it filled that volume at that temperature alone, without the presence of the other. The total pressure on the walls of the container is the sum of the two pressures, called *partial pressures.*

For instance, assume that there are two chambers, each of one cubic foot volume, side by side, with an intervening partition. Fill one with steam and the other with air, both at atmospheric pressure (14.7 lb. per sq.in. absolute pressure), and a temperature of 212 deg. F. Now, remove the partition between the two chambers and mix the steam and air. Before the two were mixed, the steam would have begun to condense as soon as it lost heat at 212 deg. F. After mixing, it would not begin to condense until the temperature is reduced to 176.85 deg. F. This is because the steam behaves in the mixture as if it were occupying all of the space alone, without the presence of the admixed air. The act of mixing has doubled the volume of the steam, and from steam tables it can be observed that at 176.85 deg. F. the volume of saturated steam is double that of steam at 212 degrees.

In the mixture, just after mixing, the steam exerts part of the pressure and the air the remainder; each possesses the same properties as if it filled the space alone, at that partial pressure.

It follows (as further illustration of this principle) that if this mixture were kept at a temperature of 212 deg. F., the steam would not condense until the mixture has been compressed to a volume of one cubic foot. The steam and the air then each have an absolute pressure of 14.7 lb. per sq.in. (zero, gage), or the total pressure is $2 \times 14.7 = 29.4$ lb.; that is, double the original pressure at which the steam alone would have condensed at 212 deg. F.

When there is nothing in the system but pure ammonia, the pressure in the condenser depends on the temperature of the cooling water, the area of the condenser surface and the rate of heat transfer. The pressure and temperature of the condensing ammonia are then related to each other as in the ammonia tables.

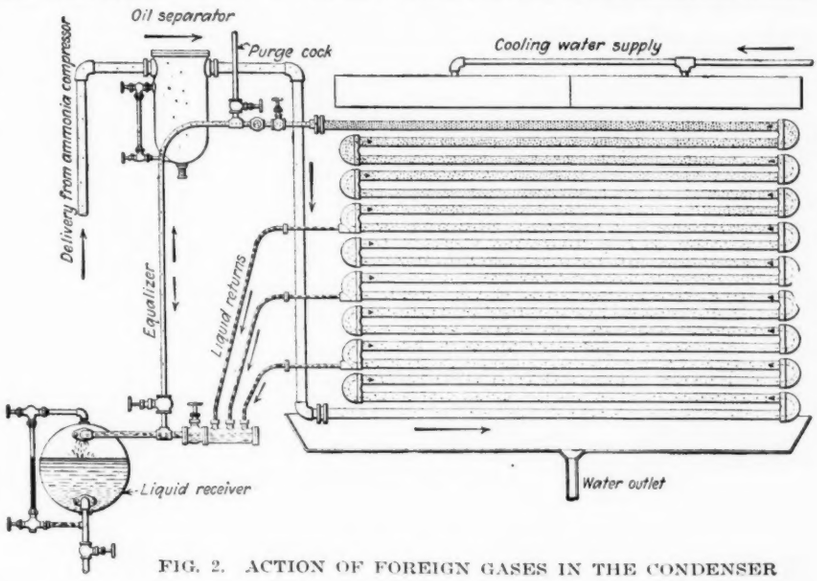


FIG. 2. ACTION OF FOREIGN GASES IN THE CONDENSER

Foreign gases present *increase the pressure in the condenser* by the amount of their partial pressure in the same way as in the example of air mixed with steam, resulting in more work for the compressor to do.

Take a numerical illustration. Neglect, for simplicity, the difference in temperature between cooling water and the vapor in the condenser and suppose the lowest available condenser temperature to be 90 deg. F. Pure ammonia vapor, according to the ammonia tables, will condense at a pressure of 180.7 lb. per sq.in. absolute (180.7 — 14.7 = 166.0 lb. gage). Suppose that we add to this ammonia one-fourth its volume of air, at the same pressure and temperature, just as we added the

air to the steam. A similar calculation would show that the ammonia in this mixture would not condense at 180.7 lb. absolute (166 lb. gage) unless the temperature were reduced to about 76 deg. F.

To get this mixture to condense at the available temperature of 90 deg. F., the mixture must be compressed until the 125 per cent volume is reduced to 100 per cent, when the absolute pressure will be about 226 lb. per sq.in. (211 lb. gage). In other words, the compressor must work against an extra pressure of about 45 pounds.

This example shows only one reason why foreign gases cut down the efficiency of the refrigerating system. The second reason is that while the ammonia is condensing, there is a strong tendency for the foreign gases to get between the ammonia vapor and the cooling surface of the condenser, preventing their being cooled. As a result there comes to be a larger difference between

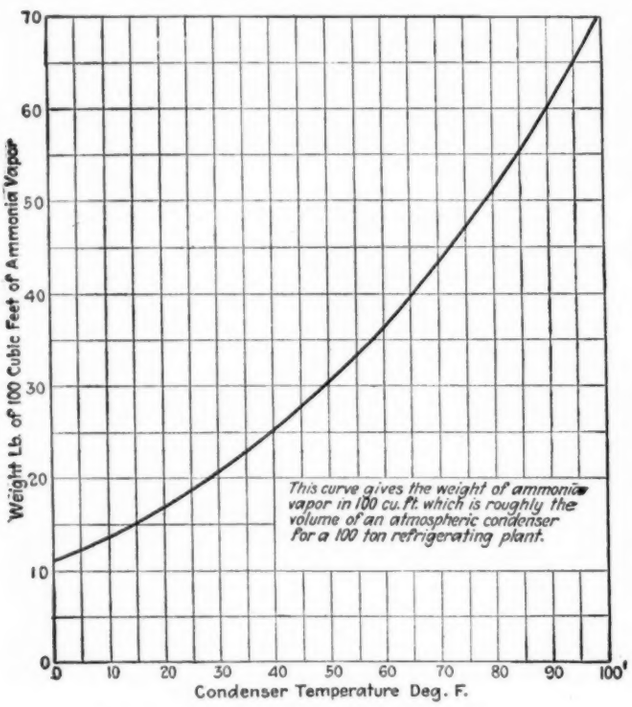


FIG. 3. WEIGHT OF AMMONIA VAPOR AT VARIOUS TEMPERATURES

the temperature of the cooling water and that of the ammonia vapor than there would be otherwise. In the case of the example if the temperature of the vapor were increased by such a cause from 90 to 100 deg. F., the pressure of the mixture would be increased to about 265 lb. absolute (250 lb. gage). This makes the delivery pressure of the compressor about 84 lb. per sq.in. higher than it would be if no foreign gas were present.

Such losses as indicated in this example are extreme, but repeatedly occur in practice, in spite of the fact that they are easily avoided.

If we trace the movements of the foreign gases in the condensing system, it will throw much light on the question as to where they can be best withdrawn and how it can be done with the least possible loss of ammonia.

Fig. 1 illustrates diagrammatically a section of pipping of the ammonia condenser. Outside is the cooling water, which cools (absorbs heat from) the metal of the pipe. At the right the larger arrows indicate ammonia vapor entering. With it, indicated by the small arrows, are foreign gases.

The metal of the pipe cools (absorbs heat from) the mixture as it advances, resulting in condensation of an outer layer of the ammonia vapor. This turns to liquid, which goes to the bottom of the pipe. The gases that were mixed with this layer of ammonia are not condensed, but form a film that bars contact between the pipe wall and the inner layers of ammonia until this outer film is dissipated by mixing with the remainder.

As the stream of mixture advances, condensation of the outer layers of ammonia vapor, formation of the insulating gas film and its partial dissipation continue. In the stream the percentage of ammonia is constantly decreasing. As shown before, increasing the proportion of foreign gases lowers the temperature at which the remaining ammonia will condense. For this reason, when a condenser is more or less airbound, the first part only of the condensing surface is working; this may often be detected by passing the hand over the pipe surface. In an atmospheric condenser, for instance, the bottom pipes into which the ammonia first passes will be perceptibly warmer than the water, while some of the upper pipes will be of the same temperature as the water, if foreign gases are present in appreciable quantities.

The conditions just described amount to a decrease of the effective area of the condenser surface, reducing its capacity and that of the plant.

Foreign Gases Swept Forward with Ammonia Vapor

As to the movements of the foreign gases, it is seen that they are swept forward with the ammonia vapor, in the direction of its travel, with constantly decreasing temperature, the gases becoming more dense—that is, mixed with less vapor—up to the point where the partial pressure of the ammonia vapor corresponds to the lowest temperature that the cooling water will give it. This generally leaves a very considerable proportion of ammonia mixed with the gases, even at the point where they are most densely collected.

The proper location for the purge connection and the effectiveness with which its operation can be accomplished depend much on the type of condenser.

Fig. 2 represents diagrammatically an atmospheric condenser in which the ammonia vapor enters the bottom pipes. Here the superheat of the vapor is removed. Following this, condensation begins, the liquid draining off to the liquid receiver from the various bends by the small pipes, shown. The last few pipes at the top have no liquid drain connections, but the top pipe is connected to the ammonia receiver by an equalizing pipe. This avoids the possibility of drawing the liquid back into the condenser from the receiver in case the latter should develop a greater pressure at any time.

In this type of condenser the purge connection is close to the point where the equalizing pipe leaves the top of the condenser.

Effect of Gas Flow

The question is asked, Will not the foreign gases, mainly air, pass down into the receiver on account of their weight, which is greater than that of ammonia vapor? Other things permitting, they would. But it should be remembered that conditions of flow have much stronger influence on the motions of these gases than gravity.

The main flow in a condenser of this type, and the removal of part of the vapor by condensation, tends to carry the gases to the top coils of the condenser, as shown on the diagram by the distribution of dots. If the ammonia receiver is colder than the top of the condenser by ever so little, the gas-vapor mixture in the top of the condenser will be drawn down to the receiver, owing to condensation of vapor there. In this case the answer to the foregoing question is yes, and the place to withdraw the gases would be from the receiver.

But nearly always the ammonia receiver is in a warmer place than the top of the condenser, which is flooded with the coldest available water. In that case there will be a tendency for liquid in the receiver to evaporate, pass up the equalizing pipe and become condensed in the top pipe of the condenser. This action prevents the gases from passing down to the receiver. Since this is the condition most frequently found in practice, the design is correct when the purge connection is placed at the top of this condenser.

In any counterflow condenser that has a down flow of water and an up flow of vapor, it is correct to say that the purge should be taken from the top, because the vapor, and therefore the gases, are flowing in that direction, and it is the coldest part of the condenser.

As the mixture becomes leaner in ammonia vapor and richer in foreign gases, the temperature falls, but it will not, of course, fall below that of the cooling water.

Location of Purge Opening

The real criterion, then, as to where the purge connection should leave, is not a matter of top or bottom. The foreign gases should be withdrawn from the point in the condensing system where the temperature of the gases and vapors is lowest. This may not be where the water is coldest, and in exceptional cases it may not be in the condenser at all, but in the ammonia receiver or in some other place.

The process of purging is generally carried out by connecting a rubber hose to the purge connection, dipping the end of the hose in a pail of water, while the valve is slightly opened. The discharge at first contains a mixture of ammonia vapor and foreign gases. The former is instantly taken up by the water, while the latter rises to the surface as bubbles. When the gases have passed out and only ammonia is left, all is taken up by the water, and the bubbles no longer rise, but a cracking sound is heard, as when a steam pipe discharges into cold water.

The water soon becomes saturated with ammonia, and if it is not replaced, the cracking sound will not be heard in the pail.

Too often the amount of ammonia lost in this process receives no thought on the part of the operator. Its amount can be roughly estimated by the following method:

Fig. 3 gives a curve for the weight of ammonia gas in a condenser volume of 100 cu.ft. This is roughly the volume of an atmospheric condenser for a plant of 100 tons capacity per 24 hours. The curve is plotted against temperature. The weight of the ammonia vapor in this condenser depends only on the temperature. If the pressure is more than the ammonia tables indicate that it should be, the difference is due to gases, but their presence does not change the amount of ammonia vapor as estimated from the temperature.

If it is necessary to purge out half the contents of the condenser, then, for a condenser temperature of 90 deg. F. there will be a loss of half of the 60 lb. of ammonia indicated by the curve.

This estimate in itself is of little value, but an inspection of the curve shows that if the temperature can be decreased, the loss is rapidly decreased. For instance, if the gases can be reduced to 50 deg. F. the loss by purging is only one-half that at 90 deg., and at 30 deg. F. the loss is only one-third.

Operation of Gas Cooler

On this principle is based an apparatus sometimes used, so arranged that the gases from the purge connection of the condenser pass to a double-pipe cooler, which is cooled either by direct expansion ammonia or by brine from the brine tank. This cooler can be small, and the gases should pass upward, so that as the ammonia vapor in them is condensed, it will run back and can be drained to the receiver. The gases are drawn off at the top of this cooler very slowly, so that they are thoroughly cooled before leaving. These are discharged into a bucket of water, as in the usual method, but the valve is opened so very little that bubbles are barely seen to rise, and the purging is continued for hours or days, until the momentary opening of the valve wider gives the characteristic cracking sound that indicates pure ammonia vapor.

The method just mentioned is scarcely applicable to all plants, but when the location of the condensers permits its convenient installation, this purge cooler is simple to make and saves much ammonia.

The presence of foreign gases in the ammonia system is so detrimental to economical plant operation that this condition should be carefuly watched. Even at the risk of a considerable ammonia loss, it is generally profitable to purge if there is any indication of foreign gases from a comparison of the temperature and pressure in the condenser. With apparatus so arranged that purging can be done economically, there is less temptation to let conditions run when gases are present.

Insufficient Engine Foundation

In foundations installed for some years, parts that are exposed to oil drippings become rotten. These portions should be cut away and renewed with neat concrete. Frequently, the foundation proves to be too small to support the engine adequately. It then becomes necessary to devise ways and means of increasing the foundation footings. Some engineers merely trench around the old footing and add a few feet of concrete. Unfortunately, the new and old concrete always fail to unite with any measure of bonding. The only satisfactory correction of this trouble is "rafting."

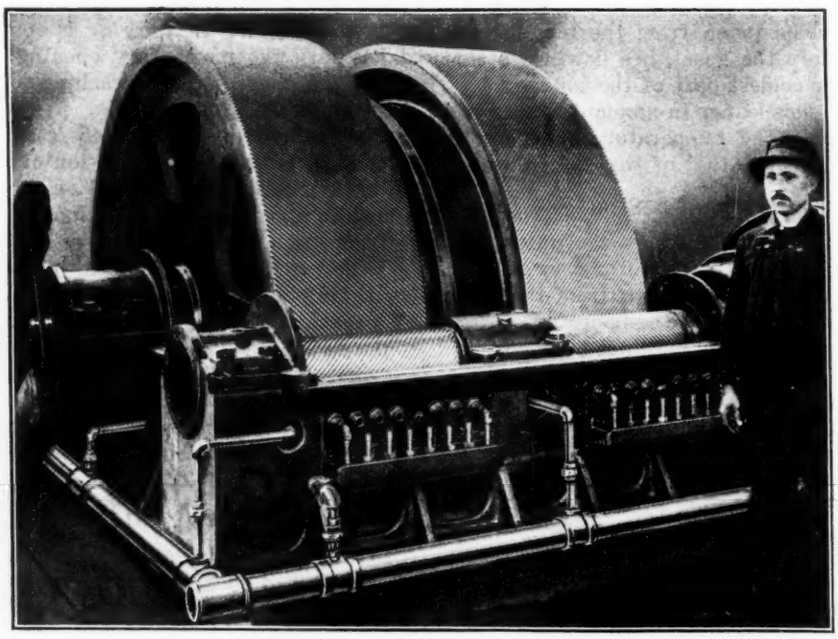
A trench should be dug completely around the engine foundation; the bottom of the trench should be at least 4 feet below the foundation base. Three or more tunnels about 4 feet high and 6 feet wide should be driven transversely under the foundation. These tunnels connect with the trench and are filled with concrete as is also the trench. If the vibrations have been excessive, it is advisable to fill the tunnels with concrete and remove the earth from between the tunnels, filling these voids with concrete. This increases the entire foundation depth by the height of the tunnels. The footings can be extended to any desired width. Many instances of warm bearings on engines using outboard bearings are directly traceable to a shifting or settling of the foundation.

Lubricating Reduction Gears

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

DURING the working period of a pair of gear teeth—that is, when a tooth of one gear is in contact with a tooth of another gear—part of the time the teeth are in rolling contact and the rest of the time they are in sliding contact. The area in contact is extremely small, and the pressure per square inch of contact on a normally loaded gear is many thousand pounds. If the metal were perfectly non-elastic, there would be only line contact and the unit pressure would be infinite, in which case there could be no film whatever and lubrication would be useless.

However, the metal is elastic and the teeth are slightly flattened at the point of contact, the width of the flattened band depending upon the elasticity of the metal and the load. When the unit load is so great that it exceeds the elastic limit of the metal, then permanent deformation will occur and wear of the teeth will take place. The unit load that any tooth can stand must be such as will not cause a permanent deformation. Such being the case, the width of the band will always be very small, and the unit pressures somewhere below the elastic limit of the metal. Except when the gear is so lightly loaded and speeds are so high that time is not given for the oil film to be squeezed out, it is doubtful whether a film exists directly under the center of the band of contact.



REDUCTION GEAR FOR TURBINE DRIVE

When the teeth are in rolling contact, the high unit pressures very likely squeeze the oil out in front of the teeth on the advancing side and prevent the formation of any kind of a complete film at the band of contact. On the retreating side of the teeth the adhesion of the oil causes it to be sucked into the space between the teeth, and upon examination they appear to have been heavily coated with oil, although actually there may have been no oil at all between the surfaces while in contact. It seems probable that a high-viscosity oil would withstand the squeezing action better than a low-viscosity oil and would therefore have a greater tendency to form a film, at least under that portion of the teeth where the pressures were not so great as to exclude the oil entirely.

During the period when the teeth are in sliding contact, we might expect that the oil would be drawn between the teeth because of its adhesion to the metal and the presence of a wedge-shaped opening along the entire length of the tooth. The angle of this wedge is very steep in comparison with its depth, and it is doubtful whether the wedging action of the oil is sufficient to form a very satisfactory film. It would seem that a high-viscosity oil would have a better chance to lubricate under such conditions than a low-viscosity oil.

If conditions are so opposed to the formation of a film, how then do we get any benefit at all from the use of oil? We know that gears running without oil will soon get hot and cut themselves to pieces and that by using oil the friction can be reduced. We know, too, that when gears do not run in a bath or under a stream of oil, a very high-viscosity lubricant that will stick to the gear teeth will reduce the wear, whereas a low-viscosity lubricant that does not stick is quite worthless.

We must admit that the adhesion of the oil to the teeth and its viscosity must have some beneficial effect on the lubrication of gear teeth. Just how it is accomplished is not entirely understood at the present time. Possibly its value is in the reduction of the friction at the edges of the band of contact before the pressures become so great as to exclude it entirely. Perhaps, too, the absorption of the oil into the pores of the metal may have something to do with the reduction of friction.

The correct viscosity depends on the speeds, the method of lubricating the teeth and the requirements of any bearings that might also have to be lubricated from the same oiling system. So far no fundamental principles have been worked out that can be used as a basis of calculating the correct viscosity—we still have to depend entirely upon practical experience with various oils in order to be able to make a satisfactory recommendation.

Turbine reduction gears are lubricated by one of two methods, bath lubrication or the spray system, the latter being the most widely used. The bath method

consists in placing a quantity of oil in the bottom of the gear case so that the teeth will dip while running. The teeth pick up a quantity of the oil and carry it to the point of meshing. When the gears are running slowly, this method is satisfactory provided a sufficiently viscous oil is used. A high-speed gear will throw the oil off by centrifugal force, although a viscous oil will adhere better under such conditions than a thin oil. We might expect that the depth of the bath would have considerable effect on the frictional resistance of the gear passing through it. When the gear is running slowly, the frictional resistance will vary with the depth, the viscosity of the oil and the speed of the gear. When running at high speeds, however, the windage of the gear prevents the oil from filling up the spaces between the teeth, reducing the friction and in fact frequently preventing the oil from coming in contact with gear at all. Obviously, when speeds are as high as this, the bath method of lubrication is not very satisfactory, because the teeth get no oil and there is metal-to-metal contact.

Most high-speed turbine gears are lubricated with oil applied very close to the point of mesh in such a manner that the oil will be drawn between the teeth. A large quantity of oil is required because a small stream will be thrown away from the gears by the windage. With a flood of oil delivered in such a manner, the viscosity need not be so great as is required for the bath system of lubrication. We might say that the difference in the requirements is somewhat similar to the difference in the viscosity requirements of the drip cup and circulatory systems of bearing lubrication.

Kind of Oil

Turbine reduction gears nearly always are lubricated from the same system that lubricates the gear bearings and the turbine bearings. This necessitates the use of an oil that will take care of both requirements. Bearings require a lower viscosity that can be used on the gears, and if an oil viscous enough for the gears is used on the bearings, excessive friction and high bearing temperatures will result. Furthermore, the viscous oil will not separate from moisture and other foreign matter readily and there will always be danger of emulsification.

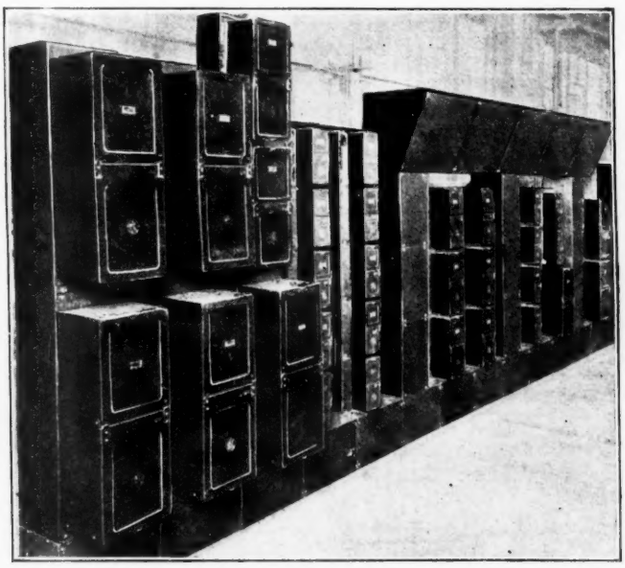
There are two ways to handle such a problem. Select an oil of the proper viscosity at the normal operating temperature of the bearings to take care of their lubrication. Then cool it down to the correct viscosity for the gears with suitable coolers. The oil should be passed through the cleaning equipment first, before cooling for the gears. The oil going to the bearings should not be cooled below the temperature that will give the correct viscosity. If it is not possible by such cooling to secure a high enough viscosity for the gears, the alternative is to use a higher viscosity oil and permit the bearings to run at a little higher temperature. Gears are much more expensive to replace than bearings, and their lubrication should be considered first, even at the expense of the bearings.

Having once selected the correct viscosities for both gears and bearings, the temperatures throughout the entire system should be controlled in such a manner as to maintain the oil at the correct viscosity when being delivered to both bearings and gears. Under these conditions the problem of gear lubrication can be solved.

Safety Inclosed Sectional Switchboard

A switchboard that has several claims to interest has recently been installed in the Stock Exchange Building, New York City, by the General Electric Co. It is the largest board of its kind to be installed as yet, consisting of 84 safety inclosed switches mounted together (part of which is shown in the figure) and used to control the lighting and power circuits of the building. These safety inclosed switchboards, which are a comparatively new development, are so designed that they may be built up as occasion arises.

The board in question handles the 250-volt direct-current power supply, and the 250- to 125-volt lighting



PART OF SAFETY INCLOSED SECTIONAL SWITCHBOARD FOR CONTROLLING POWER AND LIGHTING CIRCUITS

circuits, the units comprising it being divided into switchboards handling from 5 to 20 circuits each. Each group is fed through a remote-control double-throw solenoid circuit breaker on the main switchboard. One reason for adopting this type of board was that it was desired to meet existing conditions in the engine room, and the flexibility of the sectional board is such that this is accomplished satisfactorily.

The board itself is made up of a series of horizontal bus boxes mounted end to end and forming a sort of duct for carrying the feeder and distribution wiring of the board. The wiring units for the individual switches are secured to the bus boxes in vertical columns, which may be added to as desired and on which the switches themselves are mounted. Copper connections are used throughout, a bus being run in the horizontal duct, or bus box, and tapped at the vertical tiers, or columns. The vertical boxes are drilled at points back of the switches, and terminals supplied. From these points insulated wire is run through knockout entrance holes in the back of the switch casing to the switch studs.

Specific gravity of a solid or liquid, abbreviated sp.gr., is the name given to the number obtained by dividing the weight of a given volume of that substance by the weight of the same volume of distilled water at a temperature of 39.2 deg. F.

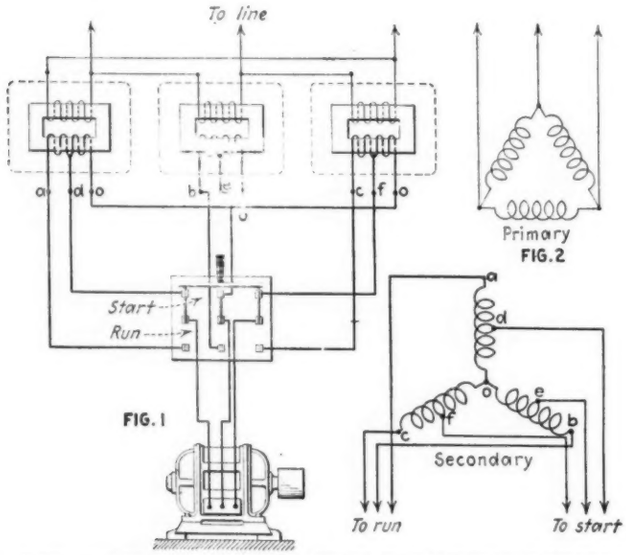
Transformers for Motor Starting

Methods of Supplying Reduced Voltage for Starting Alternating-Current Motors—Starting Motors From Taps on Power Transformers—Starting Rotary Converters—Auto-Transformers for Motor Starting

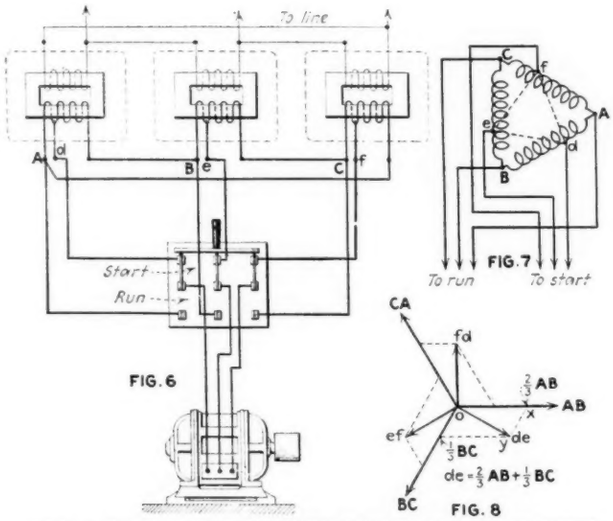
By J. B. GIBBS

Engineer, Transformer Department, Westinghouse Electric and Manufacturing Company

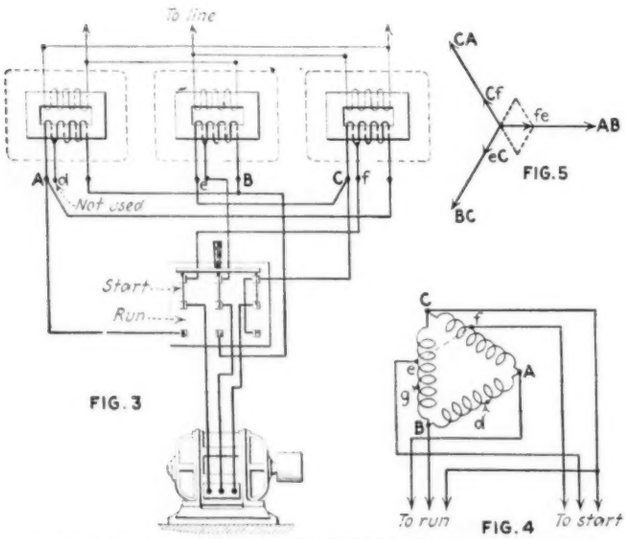
WHEN a motor is started by connecting it directly to the line, the initial current which it draws may be many times its full-load current. In motors below 5 hp., the impedance is high enough so that the starting current at full voltage is in general come up to speed and then applying the full voltage. Motors as large as 25 hp. are sometimes started by connecting them directly to the line, but it is better practice to provide starting devices for motors above 5 hp. The reduced voltage for starting is usually



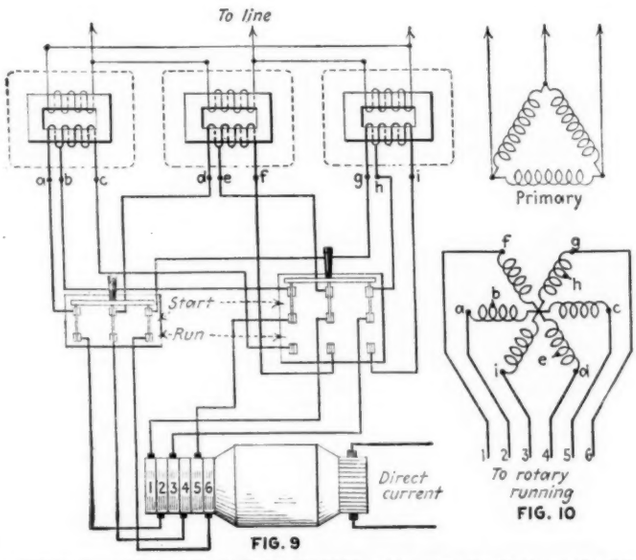
FIGS. 1 AND 2. CONNECTIONS FOR STARTING MOTORS WITH TRANSFORMERS SECONDARIES CONNECTED STAR



FIGS. 6 TO 8. CONNECTIONS FOR STARTING MOTORS WITH TRANSFORMER SECONDARIES CONNECTED DELTA; THREE TRANSFORMERS FOR STARTING



FIGS. 3 TO 5. CONNECTIONS FOR STARTING MOTORS WITH TRANSFORMER SECONDARIES CONNECTED DELTA; TWO TRANSFORMERS FOR STARTING



FIGS. 9 AND 10. CONNECTIONS FOR STARTING ROTARY CONVERTERS SUPPLYING TWO-WIRE DIRECT-CURRENT SYSTEM

not excessive, and such motors do not need special starting devices; but the starting current of a large motor at full voltage might give a considerable "bump" to even a fair-sized power system. Such motors are usually started by applying a reduced voltage until they supplied from auto-transformers, or "compensators." Sometimes large motors are run from a separate transformer bank, and in this case special taps may be provided in the transformer winding to give the required starting voltage.

The starting scheme to be used when a motor is run from its own bank of transformers depends on the connection of the transformers. Fig. 1 shows a method used if the transformers are star connected on the secondary, and Fig. 2 is the corresponding schematic diagram. Starting taps in the three transformers give the necessary starting voltages, and the motor is connected to the taps to start and to the ends of the three windings to run. The taps must, of course, be located

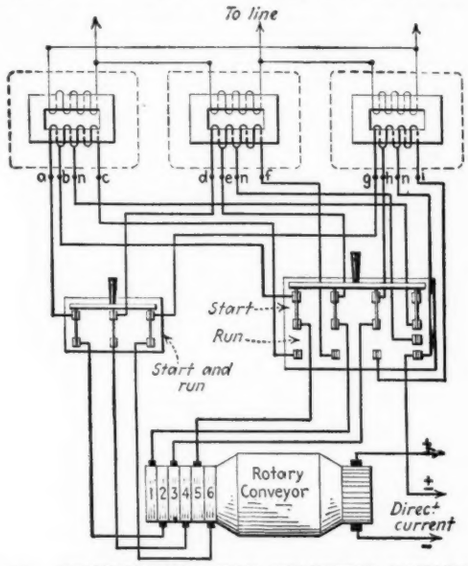


FIG. 11. CONNECTIONS FOR STARTING ROTARY CONVERTERS SUPPLYING THREE-WIRE DIRECT-CURRENT SYSTEM

when the transformer is built. It is difficult, if not impossible, to tap a completed transformer coil so as to get a specified starting voltage; 50 per cent starting voltage can usually be obtained from standard transformers, but this is frequently too low to bring the motor up to speed.

If the transformers are delta connected on the low-voltage side, two starting schemes are possible. The one generally used is to start on open-delta taps and run on the closed-delta windings. The connections for this arrangement are shown in Fig. 3, and the schematic diagram in Fig. 4. The starting connections are taken off from one corner of the secondary delta, leaving one of the transformers out of use during the starting period. In Fig. 3 it will be noted that both primary and secondary windings of one of the transformers are reversed. This is to bring the tap e near the corner C of the delta, as shown in Fig. 4, so that the leads C, f and e can be used for starting. The three transformers are made from the same design, and if one were not reversed the tap would fall at g, Fig. 4, instead of at e, and the leads C, f and g would not give a balanced three-phase voltage. The vector diagram for this connection is shown in Fig. 5. AB, BC and CA are the voltages across the three transformers. Cf is the tap voltage of one transformer in the direction of CA, and eC is the tap voltage of the other transformer in the direction of BC; fe is the vector sum of fC and Ce. This construction is shown by the dotted lines. Any desired starting voltage can be obtained with this connection. Figs. 3 and 4 show that the lead C is connected to the motor in both positions of the starting switch. If this lead is carried directly to the motor instead of to the starting switch, a two-pole switch may be used instead of the three-pole, shown in the diagram.

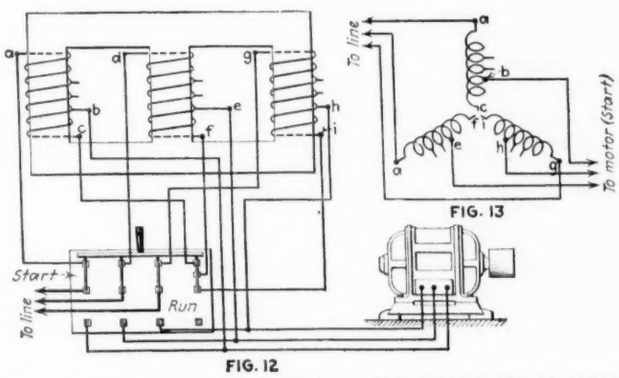
Another starting scheme, which is sometimes used when the secondaries of the transformers are connected in delta, is called "inside delta taps." The connections are shown in Fig. 6 and the schematic diagram in Fig. 7. By putting a tap in the low-voltage winding of each of the transformers, a small delta, fde, is obtained, shown by the dotted lines in Fig. 7. This gives a starting voltage lower than the running voltage, which is shown by the triangle ABC. Fig. 8 is the vector diagram assuming that the tap voltage is one-third of the secondary voltage of the transformer. AB, BC and CA are the three secondary voltages; de is evidently from Fig. 7 the vector sum of $\frac{2}{3}AB + \frac{1}{3}BC$. This construction is shown by the dotted lines in Fig. 8, where de is one side of an oblique triangle oxy whose other two sides are, respectively, ox $(= \frac{2}{3}AB)$ and xy $(= \frac{1}{3}BC = \frac{1}{3}AB)$. The angle between ox and xy is 60 deg., and by the law of cosines

$$de = AB\sqrt{\tfrac{2}{3}^2 + \tfrac{1}{3}^2 - (2 \times \tfrac{2}{3} \times \tfrac{1}{3} \times \cos 60 \text{ deg.})} = 0.571\,AB$$

that is, if the full voltage AB was 440, then the starting voltage would be $440 \times 0.571 = 251$ volts. The smallest voltage that can be obtained with this connection is one-half of the secondary voltage of the transformers.

For starting rotary converters, several different plans are used. Figs. 9, 10 and 11 show a scheme that is frequently used for six-phase rotaries which are self-starting from the alternating-current end. Each of the three transformers is connected across a diameter of the rotary winding, thus giving six points for connection to the rotary, as shown in Figs. 9 and 10. For starting, the tap voltages ab, de and gh are connected across the rotary, instead of the full secondary voltages of the transformer.

If such a rotary is to be used to supply a three-wire direct-current circuit, the neutral points of the three transformer secondaries may be connected together and this common point may be connected to the neutral wire of the direct-current circuit. In this case



FIGS. 12 AND 13. CONNECTIONS FOR STARTING MOTORS WITH THREE AUTO-TRANSFORMERS

the three transformer neutrals must, of course, be disconnected while starting. This requires an extra pole on the starting switch, and the connections are shown in Fig. 11.

The switch shown at the left in Figs 10 and 11 is frequently omitted, and these three leads are run directly to the slip rings of the rotary. Rotary converters usually have separate transformer banks, on account of the odd voltage necessary to connect to the slip rings, and these transformers are disconnected from the primary lines when the rotary is not in use.

No harm is done, therefore, in leaving the three transformer leads connected to the rotary. Four-pole switches for large rotaries are made in two parts. The first part engages the starting clips when thrown up and the running clips when down. The second part does not make contact when thrown up, but engages the running clips in parallel with the first part when down.

When a motor does not have its own separate bank of transformers, the low voltage for starting is usually

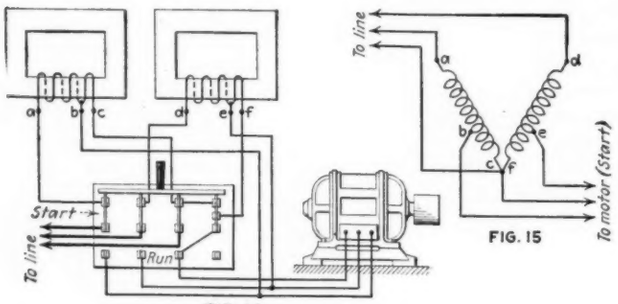


FIG. 14

FIG. 15

FIGS. 14 AND 15. CONNECTIONS FOR STARTING MOTORS WITH TWO AUTO-TRANSFORMERS

supplied from auto-transformers. Starting auto-transformers are designed for use only during the time required by the motor to come up to speed, usually one minute or less, and the material in them is therefore worked very hard, so as to make them small and cheap. They should never be left in circuit longer than the time for which they are rated, as shown on the nameplate. Even if the motor is disconnected from the auto, the primary leads of the auto should not be left connected to the line, as the exciting current may be sufficient to damage the windings if carried too long.

For large motors a three-phase auto-transformer is sometimes used. This consists of three separate coils on a three-legged core, similar to an ordinary three-phase transformer. The connections for such an auto-transformer are shown in Fig. 12, and the schematic diagram is shown in Fig. 13. For starting, the three windings are connected in star, and the starting voltage is taken from three taps, one in each winding. In the starting position the right-hand blade of the starting switch connects the three windings together at one end to form the neutral, *cif*, Fig. 13, and the other three blades connect the other ends of the windings to the line wires. The motor leads are permanently connected to the starting leads of the auto-transformer. When the switch is thrown to the running position, the neutral connection of the transformer is opened and the line wires are transferred from the transformer to the motor leads.

Another arrangement frequently used consists of two single-phase auto-transformers connected in open-delta. Fig. 14 shows the connections. When the switch is in the starting position, one end of each of the transformers windings is connected to one of the line wires and to one of the motor leads by two of the switch blades, and the other two switch blades connect the other ends of the auto-transformers to the other two lines. The starting taps are permanently connected to the motor leads. When the switch is thrown to the running position, the connection between the two auto-transformers is broken, and the line leads are transferred from the transformers to the motor leads. In Fig. 15 the simplified diagram makes the connections Fig. 14 easily understood.

Sometimes the two auto-transformers are built on a common core having a third iron leg on which there is no coil, but which serves for a return path for the magnetic flux in both the other legs. This has the advantage of making one unit instead of two and requiring slightly less material. The connections are the same as for two single-phase auto-transformers.

Two single-phase auto-transformers, either on separate cores or on a common core, are frequently mounted together with a switch and more or less auxiliary apparatus and called an "auto-starter." The auxiliary devices may include an overload trip, to disconnect the motor from the line if the load becomes excessive, and a no-voltage release to disconnect the motor if the line voltage fails. The switch is generally made so that it must be thrown to the starting position before it can be thrown to the running position, and a spring is used to that it will not remain in the starting position.

Force, Work, Energy and Power

Although the words force, work, energy and power have definite meanings, they are often imperfectly understood by the general public. This naturally makes it difficult to understand explanations where these terms are used. The average engineer, on the other hand, has a knowledge of their meaning that is almost instinctive; but it may be worth a few minutes of his time to review the definitions.

Force is the hardest to define, though the easiest to picture. In that respect it is something like *space* and *time*, terms that seem perfectly simple until one tries to define them. Briefly, *force* is that which will accelerate a mass. The ordinary unit of force in this country is the pound.

Now, what is *work?* A pillar holding up part of a building does not "work," although it exerts a large force. Work involves movement as well as force. The ordinary unit of work is the *foot-pound*. The number of foot-pounds of work done by a force is the product of the force (in pounds) by the distance (in feet) that the point of application of the force moves *in the direction of the force*. If the point moves at any angle to the force, only the part of the movement that is in the direction of the force is counted. For example, if a railway car weighing 30,000 lb. glides down an incline for 100 ft., the work done by gravity is not $30,000 \times 100 = 3,000,000$ ft.lb., but 30,000 times the vertical distance the car falls. This is so because the force of gravity acts vertically downward.

Energy is the capacity for doing work. The amount of energy is the amount of work that can be done. A 5-lb. ball held 10 ft. above the ground could do $5 \times 10 = 50$ ft.-lb. of work by falling to the floor. Hence it is said to have 50 ft.-lb. of energy.

Power unlike force, work and energy, involves time. Power is the amount of work done in a unit of time. There are several ways of expressing it. Among them are "foot-pounds per minute" and "foot-pounds per second." If it takes 4 min. to do 800 ft.-lb. of work, the power is $800 \div 4 = 200$ ft.-lb. per min. To perform the same work in 2 min., the power would have to be $800 \div 2 = 400$ ft.-lb. per min. The most common unit of power is the horsepower. One horsepower is 550 ft.-lb. per sec., or 33,000 ft.-lb. per min. Hence, to lift a 1,000-lb. weight at the rate of 90 ft. per min. requires $90 \times 1,000 = 90,000$ ft.-lb. per min., or $90,000 \div 33,000 = 2.72$ horsepower.

A New Development in High-Pressure Steam Generation

ANTICIPATING the upward trend of steam pressures, this type of boiler contains features that make it readily adaptable as a generating unit for 1,000 pounds per square inch.

THE experimental boiler installed at the Municipal Gas Co. plant, Albany, N. Y., and operated at 225 lb., was designed for high pressures by the Power Specialty Co., and developed with the co-operation of Thomas E. Murray, Inc. The economizer delivers water to the boiler at approximately steam temperature, while the latter adds heat of evaporation, and the steam is then led downward to the superheater on the rear furnace wall. The boiler and economizer contain 2-in. seamless steel tubes aggregating 1,000 and 825 sq.ft. respectively. This area corresponds to bare tube-heating surface, but the actual heating area is increased to 6,000 sq.ft. in the boiler and 5,000 sq.ft.

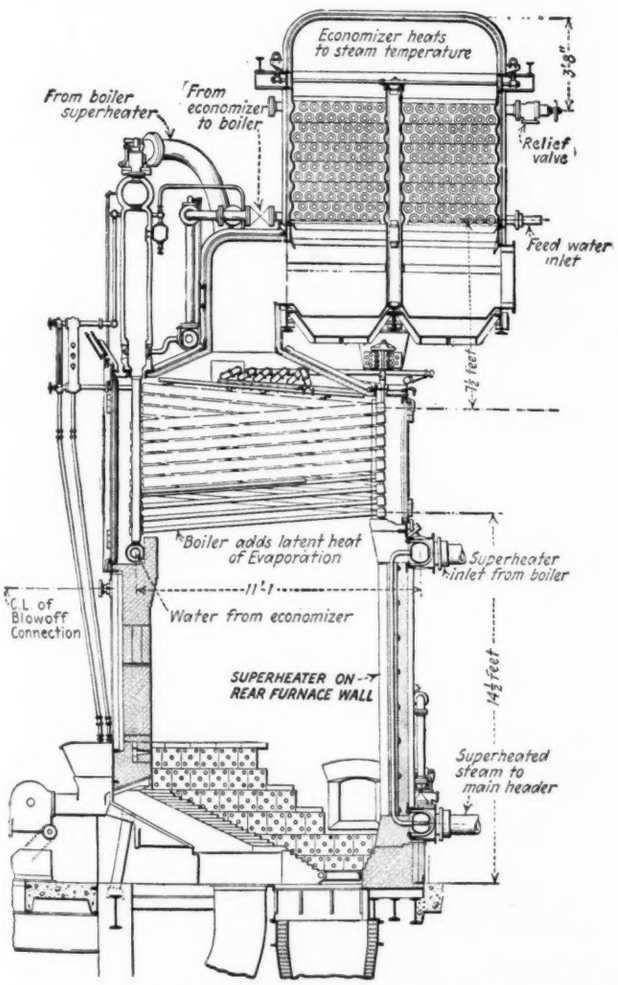

Economizer heats to steam temperature
From boiler superheater
From economizer to boiler
Relief valve
Feed water inlet
Boiler adds latent heat of Evaporation
Superheater inlet from boiler
C.L. of Blowoff Connection
Water from economizer
SUPERHEATER ON REAR FURNACE WALL
Superheated steam to main header

FIG. 1. ARRANGEMENT OF STEAM-GENERATING UNIT HAVING 6,000 SQ.FT. OF HEATING SURFACE

in the economizer by means of "gilled rings" which are shrunk on the tubes themselves.

Fig. 1 shows the usual underfeed type of stoker with high furnace setting. The four lower rows of boiler tubes are bare, while the others contain the cast-iron gilled rings. Fig. 2 shows a single unit tube complete, consisting of two straight tubes rolled into a connecting member so as to form a hairpin shape, from

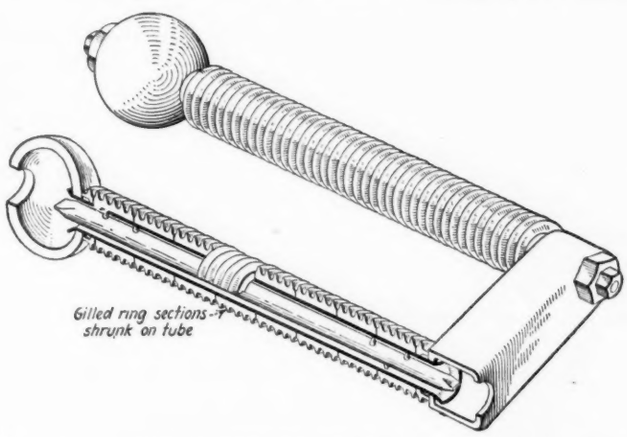


FIG. 2. HAIRPIN SHAPED TUBE WITH GILLED RINGS AND SPACERS

one header to the other. Water enters at the lower end and steam and water leave the upper. Each gilled ring section contains five rings, and is of special material. A shrink fit insures proper heat transference to the tubes. Heating surface is thus increased to about six times that of the bare tube, and the total heat transfer is increased in the same ratio over that obtained from bare tubes alone. The shrunk sections greatly increase the tube strength. A sealed spacing tube is contained internally, which forces the water and steam into a thin annular path between it and the 2-in. tube.

Fig. 3 shows the fourteen sections of boiler which receive water from a common horizontal drum, and each of which delivers steam through a vertical header into a horizontal drum. Water enters the lower end of each hairpin-shaped tube by means of a vertical water header. An equalizing pipe connects the vertical steam headers together. Since a small circular drum is much stronger for the same thickness of metal than one of larger diameter, the advantage of a large drum is obtained from a combination of small seamless structures, while better suited for high pressure.

The relatively small boiler element absorbs heat at temperatures varying from approximately 2,700 deg. F. to 700 deg. F. This produces a higher rate of heat transfer than in types with usual lower temperature of escaping gases, so that 90 per cent of the work ordinarily done by the boiler element is here accomplished with approximately 60 per cent of the usual heating surface.

Economizer Cleaned by Water Spray

Hairpin-shaped tubes, similar to those of the boiler, compose the economizer. The unit was designed for

entering gases of 700 deg. F. in order to produce feed water close to steam temperature. The relatively large economizer produced an unusually uniform escaping gas temperature over a large range of capacity, which varied from 200 deg. F. at 50 per cent rating to 290 deg. F. at 300 per cent in the tests made. A relatively low water velocity results in no appreciable drop in pressure through the economizer.

Water from the service pump at 100 lb. per sq.in., 80 deg. F. was employed in cleaning the heating surface once every 24 hours. This operation required ten to fifteen minutes and did not interfere with regular performance of duty, except in lowering the boiler-feed temperature for a period of less than one-half hour.

Superheater on Rear Furnace Wall

The arrangement of Foster Radiant Heat element superheater, Fig. 3, is a new departure, which had been thoroughly tried out in the manufacturer's plant and has the desirable feature of maintaining steady superheat over a large range of capacity as it absorbs heat mainly by radiation which is different from most present types of superheaters installed in the bank of

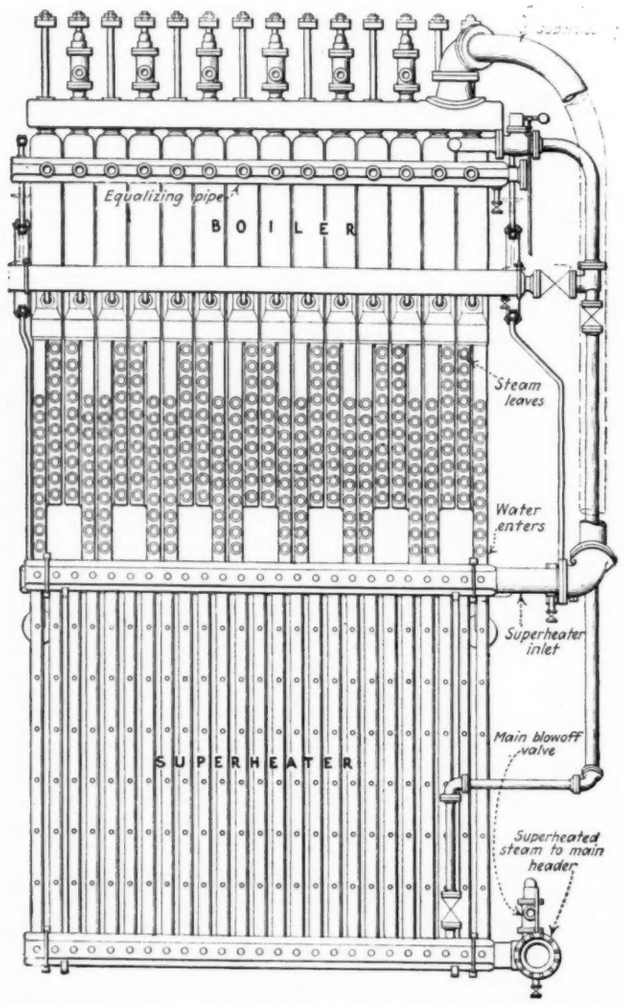


FIG. 3. SUPERHEATER PLACED BELOW SECTIONALIZED BOILER

boiler tubes and which absorb heat mainly by conduction and convection. The radiant heat element superheater, on the other hand, is not affected by the weight of gas produced and therefore gives fairly steady superheat over a large range of capacity.

Fig. 4 shows a detail of shadow brick, tubes and flat faced heat absorbers which are shrunk on the tubes. These produce 80 sq.ft. of heating surface. Reinforcing angles are bolted to these absorbers at intervals of 18 in. The amount of superheat may be adjusted by changing these shadow brick. The main blowoff valve is placed at the bottom of the superheater, while an auxiliary valve, adjusted for a higher blowoff pressure,

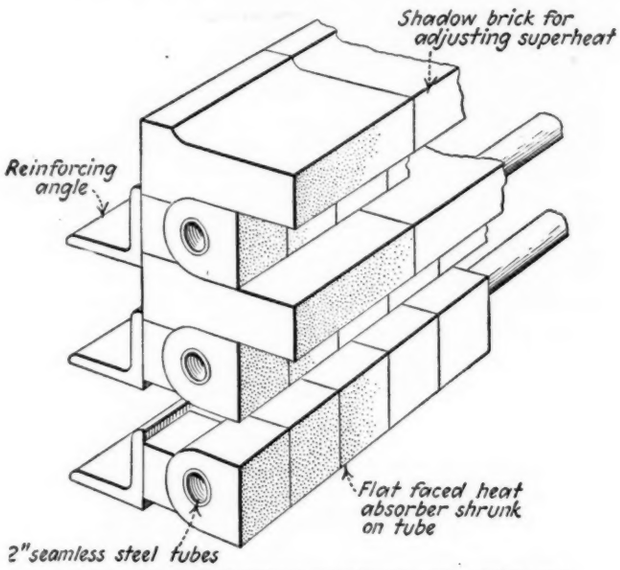

Shadow brick for adjusting superheat
Reinforcing angle
Flat faced heat absorber shrunk on tube
2" seamless steel tubes

FIG. 4. RADIANT-HEAT SUPERHEATER DETAILS

is placed on the main boiler header. Piping is led from the economizer, making it possible to flood the superheater while the fire is being raised, or whenever required otherwise. The complete steam generating unit was satisfactorily operated in regular service with

RESULTS OF TWO STEAMING TESTS

Number of Test	9	10
Date	7-29-21	8-9-21
Duration, hours	6	6
Stream pressure, lb.	202	202
Superheat, deg. F.	137	129
Feed at economizer, deg. F.	212	213
Feed at boiler, deg. F.	358	356
Temp. rise, deg. F.	146	143
Gas at flue	267	270
Gas entering economizer, deg. F.	697	663
Temperature drop through economizer	430	393
Air pressures, in. water:		
Stoker	4.00	2.50
Furnace	+.14	+.05
Leaving boiler	—.19	—.07
Leaving economizer	—1.5	—1.20
CO_2 leaving boiler, per cent	14.4	11.4
O leaving boiler, per cent	4.2	7.3
CO_2 leaving economizer, per cent	14.3	11.3
O leaving economizer, per cent	4.3	7.3
Flow meter	36,660	28,620
Horsepower developed:		
Boiler	1,042	812
Unit	1,201	935

the other power-plant boilers at any load desired. In this plant, which is mainly a stand-by station, the load varies from practically no load up to 200 or more per cent of rating. During the steaming tests the Foster steam generating unit was operated at capacities from 50 per cent to 300 per cent at the plant pressure of 225 lb. per sq.in.

The table shows the results of two steaming tests at 150 per cent and 200 per cent rating. It will be noted that there was a difference of about 3 deg. in the gas temperature leaving the economizer, also that the steel casing around the economizer was perfectly tight as there was practically no change in the gas analysis from the inlet to the outlet of the economizer.

In the past a considerable portion of the gas drop through the usual brick set economizer has been due to air infiltration and not to absorption of heat by the feed water. Part of the successful results obtained with this extended surface steam generating unit were due to the exceptionally tight steel casing designed and installed to inclose this complete steam generating unit of boiler, superheater and economizer. After an extended series of steaming tests of over three months' duration, a careful examination of the superheater failed to show any sign of distress and it has since been in regular daily operation.

It was evident from the series of steaming tests made that, provided there is sufficient pump pressure, there will be no more difficulty in maintaining a steady water level in this boiler than in any of the present-day standard types of boilers with a larger water reserve.

This steam-generating unit of stoker, boiler, superheater and economizer has been in service over an extended period, been tested under a large range in capacity, found economical as shown by the test data attached, and is now in successful daily use with the other plant boilers. With slight modifications in structure it can be built for reliable operation at pressures up to 1,000 lb. with the usual fluctuations in capacity required to be carried by modern central service stations.

During the development of this steam-generating unit the active co-operation and aid of A. Anderson, general manager, and Mr. James Meehan, chief engineer, helped considerably in its successful development.

Reeves Automatic Stoker Control

An apparatus for automatically changing the speed of a mechanical stoker, according to changes in the steam pressure, has been made by combining the ordinary type of pressure regulator with the Reeves variable-speed transmission.

The entire equipment is shown in the photograph in Fig. 1; a plan view of the speed-changing device itself

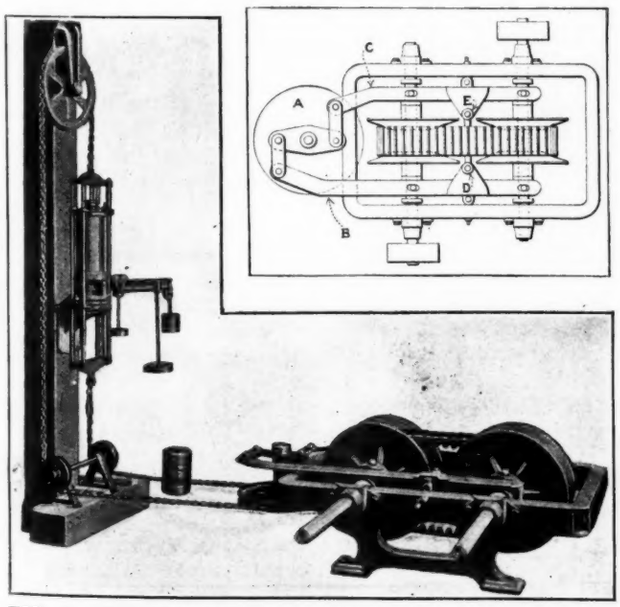


FIG. 1. THE REGULATOR AND THE SPEED-CHANGING MECHANISM INSTALLED

The variable-speed transmission is controlled through the chain and pulleys by the steam pressure in the boiler. Above is a plan view of the transmission.

is shown in the drawing in the upper righthand corner. Changes in boiler pressure are communicated to the regulator, which is fastened on to the post, in such a way as to raise or lower the two cross-pieces, which

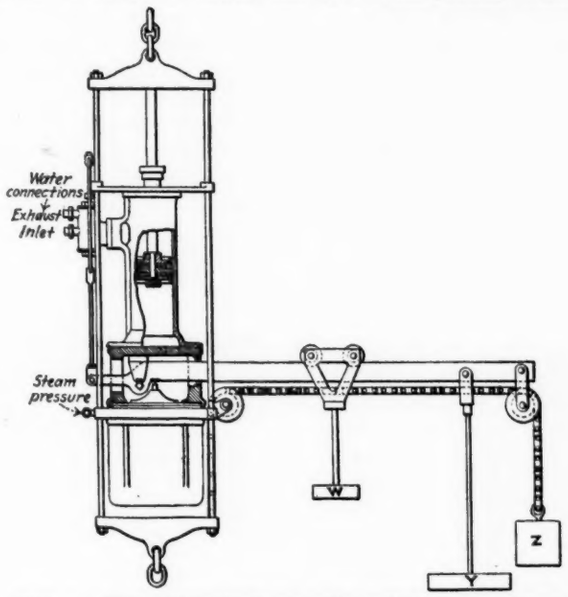


FIG. 2. CONSTRUCTION OF THE REGULATOR ITSELF

Steam pressure, acting upon a diaphragm, raises or lowers the horizontal lever, which admits water above or below the piston, thus drawing the chain this way or that and varying the stoker speed.

are connected by four rods and to each of which one end of the chain is connected. The resulting movement of the chain turns the pulley-wheel that controls the setting of the variable-speed transmission.

The operation of the transmission may be seen in the plan view at the top. The pulley on one side is driven at a constant speed by a motor, engine, or line shaft, while the pulley on the other side transmits the power at a variable speed to the stoker. The two shafts on the ends of which these pulleys are mounted are connected by a V-belt. Each of the pulleys over which this belt runs is formed by two beveled discs, which are splined to the shaft but may slide along it. Therefore, if the discs on one shaft are brought together somewhat, and those on the other shaft are drawn apart a corresponding distance, the length of the belt will remain the same, but a change will have been made in the sizes of the two pulleys and therefore in the speed of the driven shaft. The positions of these discs are changed by the pulley-wheel *A*, which, when turned, forces apart or together the ends of the levers *B* and *C*, which are pivoted at *D* and *E*.

The pressure regulator is shown in Fig. 2. Steam is admitted to a diaphragm directly under the horizontal lever, and the pressure forces a point up against the bottom of this lever near its pivot. An extension of the lefthand end of the lever is connected by a link to a valve that admits water either above or below the piston in the cylinder directly above the lever, according to whether the lever rises or falls. As long as the lever stays out of a horizontal position water continues to flow into the cylinder and to raise or lower the piston, thus moving the chain and changing the speed of the stoker.

In order to keep this change in speed from going to the extreme low or high limit, the sliding weight *W* is arranged so as to bring the lever back to a horizontal

position. Thus, when the lever is raised by an increase of steam pressure, the hydraulic piston rises and allows *W* to be drawn out somewhat by the counterweight *Z*. As soon as *W* has moved out a little way it overbalances the increase in steam pressure and brings the lever back to a horizontal position, thus preventing a further change in stoker speed until that is required by another change in steam pressure. The sensitiveness of the apparatus may be changed at will by varying the weight of *W*. The weight of *Y* may also be varied at will to suit the steam pressure that is to be maintained.

The apparatus is made by the Reeves Pulley Co., Columbus, Ind.; it may be designed for several different ratios of speed variation, up to a maximum of 14 to 1, and is made in four sizes, up to 42 horsepower.

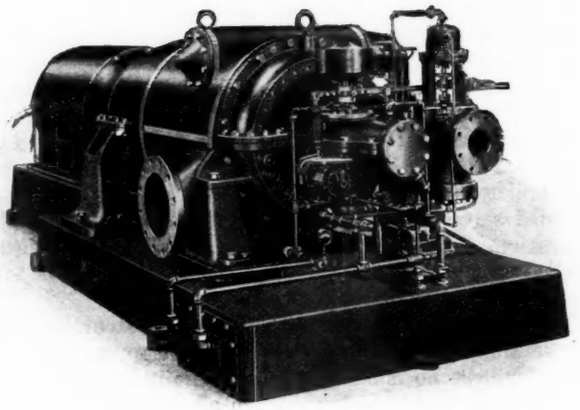


FIG. 2. BLEEDER TURBINE MAINTAINS PRACTICALLY CONSTANT PRESSURE IN EXTRACTION CHAMBER

A New Type of Bleeder Turbine

It is perhaps unnecessary to mention that the pressure within the usual type of turbine varies with the load. If a gage is placed at any point between the first and last expansions, it will show higher pressure as the load is increased. On account of the varying pressure at the point of extracting, it is therefore often necessary to place a reducing or regulating valve in the bleeder line, in order to maintain a fairly constant pressure, regardless of the usual load variation. In the bleeder turbine recently produced by the Moore Steam Turbine Corporation, pressure is maintained practically constant within the machine itself, at the point where steam is extracted.

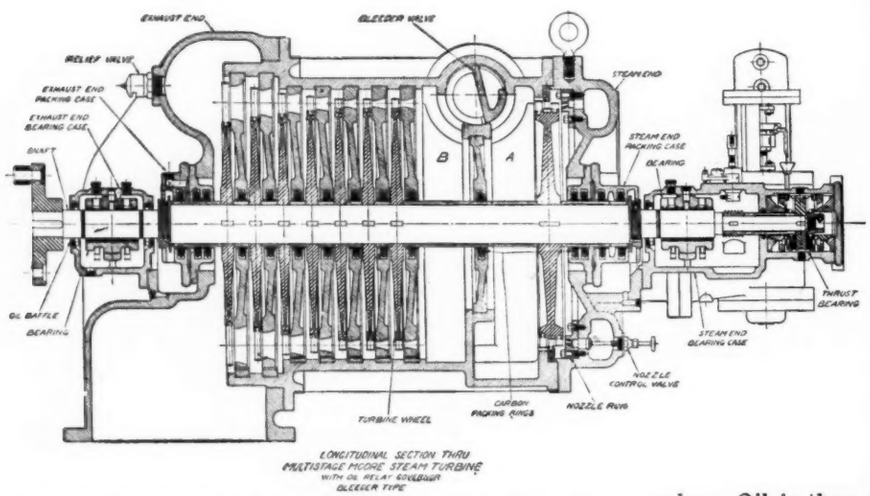


FIG. 1. STEAM TRAVERSES ONE WHEEL BEFORE ENTERING EXTRACTION CHAMBER A

An automatic by-pass valve is placed at the top of the casing, as shown in Fig. 1. The steam is expanded and traverses one wheel before entering the extraction chamber *A*. Part of this steam is allowed to pass into the remaining stages, as determined by the position of this valve, which maintains nearly constant pressure in the first stage. When light loads occur the entire amount of steam entering the turbine may be diverted into the extraction line, except for a very small quantity that is allowed to leak through the lower stages, and thus prevent high temperatures due to friction of the revolving disks.

The by-pass valve, shown in Fig. 3, is supported in a bearing at each end. This does not touch its seat appreciably, as a mechanical clearance is maintained between the two elements, which insures ease of operation. A small amount of steam is permitted by this clearance to leak into the low-pressure stages, in case the valve should be entirely closed.

Steam pressure is piped to the top of the regulating diaphragm, which acts against a spring. Increased pressure lowers the regulator, which in turn lowers the position of the oil relay or pilot valve. Oil is thus admitted to the top of the operating piston, causing it to lower and open the by-pass valve, admitting steam to the lower stages of the turbine and reducing the pressure in the extraction chamber. The regulator acts on a short lever pivoted at the left, which is in turn connected by a sliding pivot to another horizon-

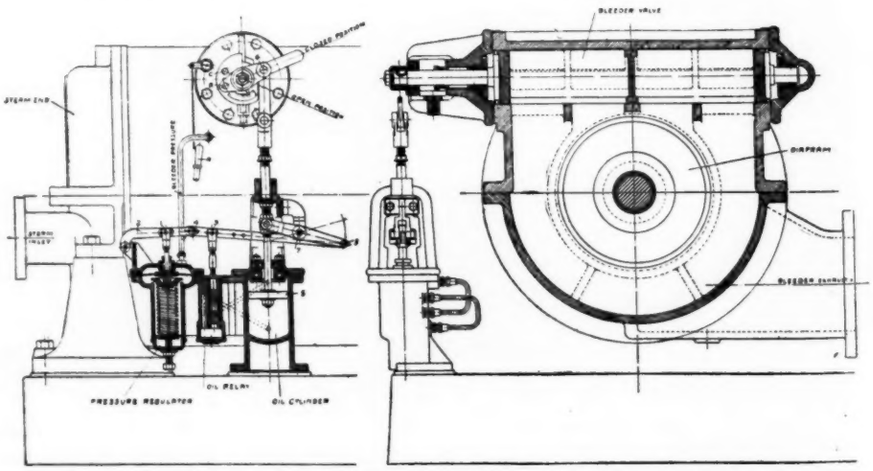


FIG. 3. REGULATING DEVICE AUTOMATICALLY MOVES BYPASS VALVE

tal lever at the right. This latter operates the oil relay, and also is connected through a pivot at the extreme right to a compensating link, attached to the piston rod operating the bypass valve. The compensating action tends to close the oil relay as the valve is opened, so as to limit the travel of the valve which is thus made proportional to the movement of the regulator. When the pressure becomes too light, a corresponding sequence of actions take place in opposite directions.

A definite increase of pressure is required to move the valve from closed to open position. The actual pressure maintained can be adjusted by means of a bolt and lock nut at the bottom of the regulator spring. A pin is provided for locking the valve in open position if desired to operate as a straight condensing turbine.

The turbine is fitted with the usual oil relay type of main governor for admitting steam according to the requirements of the load and extraction.

The process for which the steam is required may utilize the heat of saturated steam efficiently, and still be unable to utilize the superheat to advantage, causing the latter to represent waste. An appreciable rise in temperature of extracted steam due to superheat might be disastrous, if it is used in a process such as fermentation or partial distillation.

These turbines are furnished in sizes as small as 100 kw., and can be designed for bleeder pressures as high as 40 lb. per sq.in.

Ball and Roller Bearings for Use on Electric Motors

By Gordon Fox
Electrical Engineer, Freyn Brassert and Co., Chicago, Ill.

The use of ball bearings on motors appears to afford a number of advantages. There are, however, also disadvantages incident to their adoption and use. This article will mention a few of the considerations involved without reaching any conclusions in the matter.

The principal benefit afforded by ball and roller bearings arises from the fact that lubricant is effectively retained and does not work into the commutator and windings of the motor. Oil leakage from bearings is pronounced responsible for more than half our motor failures. Incidentally, the absence of oil drip may be of considerable import where cleanliness is necessary. They require less attention than other types and they have been known to survive in spite of prolonged neglect.

The wear of these bearings, if of proper design, is very slight, so that renewals are infrequent. They also retain the rotor in central position and restrict vibration, which may arise through excess bearing play. Improvement in motor efficiency is a somewhat minor consideration. The gain is, in general, on the order of one per cent. It is greater for high-speed than for low-speed motors. Ball bearings are superior to roller bearings in this respect.

Ball and roller bearings are more compact than sleeve bearings. Motors so equipped are 15 to 20 per cent shorter in overall length than motors having sleeve bearings. Where the oil may be siphoned out, as by cotton mill lint or by windage of a blower, the use of ball bearings is advantageous. They are also useful for vertical motors or where the shaft may be inclined or where subject to pitching, as on shipboard. They are also used to advantage where it is desired to eliminate all end thrust, as for self-contained grinding-wheel units.

A disadvantage of the ball or roller bearing is the difficulty connected with their renewal and with the removal or inter-change of rotors. These bearings cannot be split. The inner race must fit the shaft tightly and the bearing must be removed as a whole or dismantled in order to remove the rotor. The bearing may be exposed to dirt and damage while thus dismantled.

The refinement necessary in clearances and fits on the shaft and in the housing, and the care necessary in the proper assembly, are handicaps. Workmen may need to be trained to handle these types of bearing successfully. Spare bearings of the sleeve type are relatively inexpensive. Babbitting may be quickly done where necessary. Loss of a ball bearing where no spare is available may be a serious matter.

There is some question as to the ability of ball bearings to withstand shocks successfully. The roller bearing is probably superior in this respect. Some trouble has been caused by pitting due to acidity of lubricant. The grounding of armatures may cause pitting or burning due to current flow through the bearings.

Sleeve bearings are well established and are, in the main, quite satisfactory. Any change is undesirable unless fully warranted. The introduction of ball or roller bearings would involve considerable additional investment to motor manufacturers. Many users would be required to carry two sets of spare parts, at least during the transition period. The change involves expense which must be justified.

The cost of motors equipped with ball and roller bearings is somewhat higher than the cost of sleeve bearing motors. If two types are manufactured, the cost of both will be greater. The increase in motor cost due to ball or roller bearings is, in general, on the order of three to five per cent. A number of methods have been developed or proposed for incorporating the ball or roller bearings in motors. It may be in order to mention a few features which are desirable.

The mounting arrangement should be such as to enable the armature to be removed without the necessity of removing the bearings from the shaft. It should be possible to apply pressure to the inner race or sleeve so that the bearing may be removed from the shaft without transmitting end pull through the balls. The bearing should be protected from dirt so far as possible.

To meet these requirements a construction is favored in which the bearing is enclosed in a separate housing, which fits into the bearing bracket but which may be removed intact. The housing or container should afford sufficient space for lubricant. Provision should be made, usually in the form of labyrinth grooves, to retain the lubricant effectively. A non-acid grease lubricant is generally used for motors of moderate size and speed. This is less difficult to retain than oil. Oil may be necessary at high speeds.

Accurate machining of shaft and housing are necessary. The bearing should have a light drive fit on the shaft and should be held fixed, usually by a lock nut. The outer race should be a sucking fit in the housing and may be permitted to float. The inner race is sometimes mounted on a sleeve to distribute the pressure over a longer length of shaft. This is not necessary except for severe duty. Last but not least, the bearings should be liberal in size. Considerable trouble may be attributed to lack of conservatism in bearing selection.

Oil-Engine Bearing Clearances

By J. Spugg

Steam engineers, upon taking charge of an oil engine, are prone to follow the same general plan of adjustments that proved successful with the steam engine. The pressures in the steam engine are not so high as with the oil engine nor is the pressure change so rapid. If the engineer will compare the expansion line of any type of internal-combustion engine with that from a steam engine, the difference in pressure change will be recognized. In addition, if the engine operates in the Otto cycle, or combustion at constant volume, the increase in pressure at or close to dead center is instantaneous.

These rapid pressure changes will cause the engine to pound. This is especially true as to the connecting-rod bearing, both for the crank and piston pin. If the clearances between the pin and its bearing or brass is at all large, the pound will soon put the bearing out of shape. On the other hand, if there is just enough clearance to take care of the difference in expansion between the pin and the bearing plus a space sufficient to enable the lubricating oil to form a film, pounding may be avoided. The question of proper clearance cannot be settled by the use of any formula. Engines differ as to individual characteristics; clearance that is carried for one engine will cause another to run hot and a third engine may cause considerable pounding. However, unless the engineer knows the particular machine, these bearings should have clearances of from 0.004 to 0.007 in., depending upon the size. Some erectors start with a clearance of 0.0004 in. per inch of pin diameter plus 0.001 in. Others use still more.

Probably the best rule for the engineer to follow is to allow as much clearance as possible and still eliminate the pound. This clearance may be experimentally reduced from time to time to arrive at that condition where the operation is most satisfactory.

Excessive rod bearing clearances are not the sole cause of pounding. It will be found that after an engine has seen some years of service, the clearance between the piston and cylinder walls becomes excessive. This loose condition allows the piston to "slap," and the resulting noise is often assumed to be due to loose bearings. The difference in sound is unmistakable to one acquainted with oil engines.

The crankpin bearing often rubs the crank web so that the side clearance becomes large enough to cause pounding. A clearance here of 0.007 in. is sufficiently large. It may be reduced when excessive by running a ring of babbitt along the bearing face. The presence of much side clearance is good evidence of lack of alignment of the rod with the crankshaft. This should be corrected by realigning; if necessary the crankpin bearing can be refitted to the pin to bring the bore parallel with the top surface of the box.

The clearance of the mainshaft bearings need not be so close as in case of the pin bearings. The pressure is downward and the shaft remains seated in the lower bearing shell at all times. Even in the case of a four-stroke-cycle engine the weight of shaft and wheel will offset the upward thrust on the suction strokes. The top shell then is merely a safety measure to prevent the shaft from lifting in case conditions are not normal. There is little reason to make this clearance less than 0.0075 to 0.01 in. A small clearance might cause gripping in event of a hot journal.

Air-Cooled Furnace Blocks for Reducing Upkeep

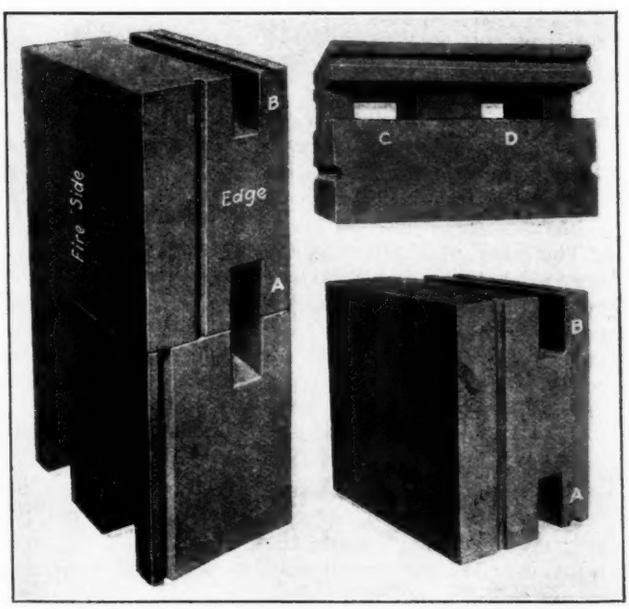
The air-cooled furnace block illustrated here has been designed to prevent the expense of continually repairing furnace walls that have been injured by the high temperature resulting from modern firing methods. The blocks are so made that, when placed together to form a wall, numerous passageways are left through them for air, so that some heat may be taken off and their temperature kept below the fusing point.

In the illustration, at the left, two of the blocks are shown as installed. The bottom one is a little different from the standard, having openings at the bottom for air inlets or outlets. It may be seen that the grooves *A* and *B* in each block form a continuous passageway with blocks above and below. These horizontal passageways are connected by two vertical openings *C* and *D* in each block, which may be seen in the view at the upper right-hand corner, showing the block as seen from above.

A furnace wall constructed of these blocks, therefore, is practically hollow and is continually cooled by a stream of cold air, with either forced or natural draft.

The air-inlet openings may be at any convenient place, and the heated air is discharged into the furnace below the grate, or behind the bridge wall, so that the heat absorbed in the brickwork will not be lost.

These blocks were first used in the rear combustion arches of oil-fired furnaces, and the manufacturers report that the results obtained under such conditions indicate the desirability of using the blocks also in the bridge wall and the side walls of all high-temperature furnaces. It is stated further that successful installations have been made in connection with stokers, using forced draft; the air is forced from the windbox into the bridge wall, from there into the side walls, and then to the discharge outlet under the grate. The blocks are manufactured by Waite & Davey Co., Inc., 9 Jackson Avenue, Long Island City, N. Y.



AIR-COOLED BLOCKS FOR HIGH-TEMPERATURE WORK

At the left are two blocks as installed, and at the right are two views of one block. The horizontal passages *A* and *B* are connected in each block by the two vertical openings *C* and *D*.

EDITORIALS

Oil Engine vs. Steam Power

IN HIS paper on the above subject, presented to the Textile Plant Engineers of Boston, and printed in last week's issue, Dr. Charles E. Lucke makes out an attractive case for the oil engine.

A steam plant that requires five pounds of coal per brake horsepower-hour has a thermal efficiency of less than four per cent. An engine that turns out a brake horsepower-hour on half a pound of oil has a thermal efficiency of some twenty-eight per cent.

If coal cost $5 a ton the fuel cost of the horsepower-hour made by steam would be 1.25 cents. If oil cost 5c. a gallon or 0.7 cents a pound the fuel cost of the oil-made horsepower-hour would be 0.35 or about a quarter as much. But it is easily possible to make eight pounds of steam per pound of coal, and there are many steam engines of comparatively small capacity that will run even non-condensing on twenty pounds or less of steam per horsepower-hour. This would cut the assumed coal cost in halves.

If an engine can develop a brake horsepower-hour on twenty pounds of steam and a boiler can make eight pounds of steam per pound of coal, i.e., 2.5 lb. of coal per brake horsepower-hour, the oil could cost five times as much per pound as the coal to make them comparable on a fuel cost basis, if the oil engine required 0.5 lb. If oil cost 0.5 cent per pound or about 4 cents per gallon coal could cost 0.1 cent per pound or $2 per ton.

There is a fighting chance for the high-class steam engine even on the thermal efficiency basis. The great advantage of the steam engine, not always appreciated and realized, is the availability of its exhaust for heating and process purposes. When a large proportion of its exhaust can be used to advantage, the steam engine becomes the cheapest available method of producing power, and it pays to run it against high back pressures in order to get the required temperature in the exhaust. It is true that over two-thirds of the heat supplied to the oil engine goes off in the jacket water and exhaust, and that the exhaust is at a high temperature, but there is as yet no generally adopted means for its retrievement.

A Lesson from the Coal Strike

ONE of the obstacles always appearing in the way of a solution of the coal-miners' wage problem has been the difficulty in giving constant employment. The demand for coal during the winter exceeds that for the summer to such a degree as to leave a considerable percentage of the miners out of employment during the summer months, or else only working a few hours each week. Seasonal storage has been considered as the solution to smoothing out this winter peak and spreading it over the summer months. However, the question has frequently been raised as to who is going to store the coal.

Urged on by the probabilities of a miners' strike, the industries and the utility companies began to store coal well in advance of April 1, with a result that some of these companies have sufficient coal to keep their plants going until next winter. After a shut down of the mines for three and one-half months it is only now that the industries of the country are beginning to feel the effects of the closing the coal mines. A recent survey of the public utilities' stocks of coal showed that on June 15 these companies had on hand an average of fifty-three days' supply, and with what they were receiving from non-union production it was apparent that their coal would last for twelve or fifteen weeks, or until about the middle of September.

These facts show that there is available adequate facilities for seasonal storage far in excess of requirements to insure continuous operation of the mines, use of the coal-handling railway equipment and constant employment for the miners. This, however, is for an adequate number of mines employing the necessary number of miners and not for an over-development as now exists. The coal-storage facilities are available. What is needed is something to encourage their use, in normal times as well as in emergency. This apparently can be done only by a seasonal rate for coal. The consumers of coal cannot be expected to stand the total cost of storage; the mine operators, miners and railroads must all bear their part. When this is done, order may be brought out of the chaos that now exists in the coal-mining industry.

Power Plant Important Factor in Manufacturing Processes

THE power plant as a factor in manufacturing processes is rapidly gaining prominence, and although at the present time it is receiving a fair share of attention, its importance has not been realized to the fullest extent.

While reliability is undoubtedly the most essential and outstanding requirement of any power plant, it is often unintentionally sacrificed by the designing engineer in his eagerness to equip the plant with all the latest labor- and fuel-saving devices.

Some engineers fail to realize that simplicity is an underlying principle of reliability. This factor, however, must be considered in the light of its effect upon the economical performance of the plant. No arbitrary ruling can be made as to what constitutes the essential and most economical equipment for industrial power plants. This can be determined only after a careful investigation of the conditions and elements involved. The operation of a plant can in many cases be simplified, without limiting the equipment to any appreciable extent, by giving special attention to the arrangement or grouping of the different units, particularly the auxiliaries, with a view to minimizing the attendance and centralizing the control.

In the leading article in this issue is described the power plant of the Follansbee Bros. Co. Steel Mill at Toronto, Ohio, in the design of which an effort has been made to combine the essential features of the modern

plant and at the same time keep the installed capacity as low as was considered consistent with economy and continuity of service.

A departure has been made from the usual practice in the layout of the building and in the placing of the forced draft fans in front of the boiler, instead of in the basement, and while the author appears to regret that the installation of a loop header was not feasible, this is in reality a step toward the most recent practice in power plant design.

The Value of Record Keeping

EFFICIENCY in the power plant is a subject that is attracting an ever-increasing interest, but the fact remains that many of the plants in operation are not designed for obtaining and keeping records that would give an intelligent understanding of what they are doing. Obtaining and keeping records of operation and utilizing these data to improve plant efficiency must be considered from the point of cost and continuity of service. In this respect the size of the plant and its design are important factors. In a large modern station the installation of recording equipment to assist in operating the machinery practically under test conditions at all times might be justified. However, in a plant that just grew, like Topsy, such records would be difficult to justify from a financial point of view.

In a plant that has a large number of hand-fired boilers, each of say fifteen hundred or two-thousand square feet of heating surface (and there are many such examples) the cost of equipment for complete records is almost prohibitive. Even if the apparatus were installed, the work necessary to obtain the data and analyze it would entail no small expense. In the station with a small number of large units the cost of equipping each with recording apparatus is nominal, and the work of keeping records can be reduced to a minimum. What is true of the boiler plant applies equally well to the prime movers and electric-generating equipment.

There is no question but that in every plant some form of records should be kept, but it is evident that the extent of the records will depend largely upon the plant. In small plants, or in larger ones where small units are used, an inspection and maintenance schedule that will keep the equipment in good repair would result in lower power costs than any elaborate system or record-keeping that is so bulky as to discourage its use. Whatever system may be adopted, its value will depend upon how rigidly it is lived up to, and not on the extensiveness of its makeup.

Boiler Oil

THE coal strike has served to emphasize the necessity of a secondary fuel to fall back upon when coal cannot be obtained. The total amount of coal used in power production far exceeds the production of petroleum, and the latter cannot be considered as a substitute in all power plants. There is, however, a large amount of boiler oil available at all times in favored localities such as the Middle West, the Pacific Coast and along the Atlantic Seaboard.

As a safeguard against shutdown due to strikes or transportation difficulties, boiler oil is worthy of serious consideration. Owing to the extreme requirements of various municipal and fire underwriters' codes, the cost of installing oil tanks in cities is often so high as to be prohibitive for the average plant; although there are notable exceptions, even in New York City, where in spite of the requirements, one large office building has, out of the savings in oil over coal, paid for the oil-burning equipment in twenty-one months. Industrial power plants, as a whole, are distributed among the smaller towns rather than massed in the cities. The plants outside the sphere of stringent regulations will find that the installation costs are little if any higher than that of coal-burning equipment, averaging around one dollar per square foot of boiler heating surface.

Plants where coal is preferred will find that auxiliary oil-burning equipment may be installed at a cost considerably below that quoted. If the storage tanks are well built there is no reason why one or two months' supply of oil may not be stored indefinitely. It is not unusual to find that refineries have oil stocks in storage for over a year with an almost insignificant shrinkage.

The usual method of comparing oil and coal on a B.t.u. basis is often misleading. In a great many plants an average boiler efficiency of sixty per cent is seldom exceeded. Including banking fires and coal wastage this efficiency is probably above the average for industrial plants. On the other hand, the efficiency with oil will average seventy per cent. This then permits an oil cost per million B.t.u. of forty per cent higher than that of coal. In addition there are decreased labor charges, elimination of ash handling and other advantages that will raise this to around fifty per cent.

With the present stock of boiler oil and the increasing production considered, it would seem that power plants should investigate the possibilities of using this oil either as a main or auxiliary fuel.

Powdered coal has received the decision at St. Louis. This is the second large central station to adopt this method of burning fuel, and the selection will serve to further stimulate the competition with mechanical stokers. The North American Company controls both the Milwaukee and the St. Louis properties, and this latest decision may be taken as an indorsement of the performance of the Milwaukee plant. It is significant, however, that the newer plant will have practically all its powdered fuel equipment located within the boiler house, thus reducing the investment charges and removing one of the objections that has often been raised against the Milwaukee installation. A more detailed description of the preliminary layout of the St. Louis plant will appear in next week's issue.

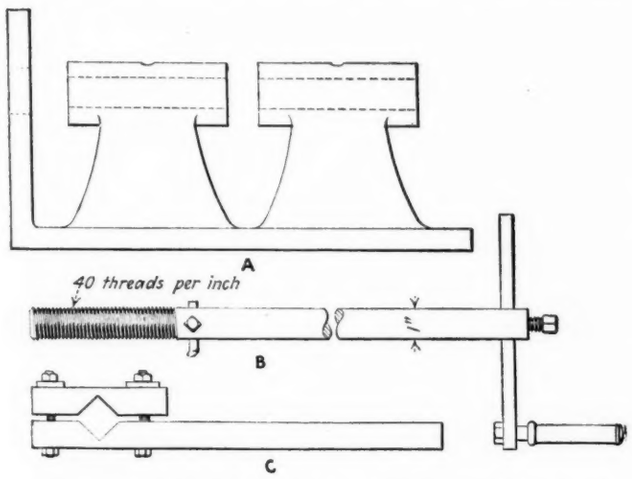
In view of the startling developments in wireless telegraphy, aëronautics and other fields, the modern engineer is a bit slow to say a thing cannot be done. At the same time he may be pardoned if he is a little skeptical when he reads in the newspapers of the wonderful performances of a "self-created scarab or beetle of old Egypt" which Mrs. Dickinson, of England, has discovered. This scarab, so the story runs, when put in a bottle and dipped into water gives the water many startling and mysterious properties, such as making coal clean, petrifying wood, killing insects, and even curing abscesses. But the power-plant engineer is not left out in the cold. This magic water will prevent scale from forming in his boilers and increase the caloric value of his coal.

The index for Vol. 55, the first six months of 1922, is now ready and will be sent to subscribers upon request.

PRACTICAL IDEAS from PRACTICAL MEN

Fitting New Crankpin in Disk

The centrifugal oiler on one of our 50-hp. vertical engines came off and the engineer put it back on and centered it by scribing a circle on the end of the crankshaft the diameter of the ball, using a square across the face of the crank disk from the edge of the circle to the ball. When we started up, the oiler was out of true. We tried several times to center it, but without success, so we put the engine on the lower dead center and, with a bar and block for a pry, found that the crankpin was loose. We cut the peening off the inside end of the pin and pulled it out by hand. After taking a few measurements, we started the machinist turning a new pin and then looked around for some apparatus to ream the hole in the crank disk.



TOOLS USED TO REAM OUT CRANKPIN HOLE IN DISC

We found a bracket as shown at *A* and planed off the face, and reamed out the holes in the bearings a snug fit for a 1-in. shaft. We then secured a piece of 1-in. shaft the right length and drilled it for the tool and handle and for setscrews to hold them, as shown at *B*. Then the question arose how to feed the tool. This was done by cutting a thread on the end of the tool bar, 40 threads to the inch, and with a clamp of hardwood, made as at *C*, and fastened on the end of the boring bar after it had been centered and fastened to the face of the disk with a couple of clamps, the tool fed itself as the handle of the tool was turned.

We reamed the hole 1 in. minus 0.001 in. for each inch of the pin's diameter. A hole was drilled in the pin's end and tapped for a $\frac{3}{4}$-in. bolt, and when the pin was entered the nut was drawn up and a tension kept on it. A 16-lb. sledge and a block of hardwood were used to drive the pin home. After scraping the boxes to fit the new pin, we finally got the engine in service again with the oiler properly centered.

Adams, Mass. JOHN H. ARMSTRONG.

Special Means of Calibrating Steam-Flow Meter

The allocation of certain losses in the power plant of the Springfield Light, Heat and Power Co., Springfield, Ohio, depended upon the accuracy of the flow-meter used in metering the flow of steam. This flow-meter consisted of a 4 x 1½ in. nozzle and a portable flow-meter (mercury U-tube). Readings of the mercury deflection were taken as often as desired in using this instrument, depending upon the period of variation of flow and the time between readings varied from 5 minutes to 30 minutes.

The following scheme was adopted for the calibration test: A 6,000-sq.ft. surface condenser was blanked off from the exhaust outlet of the turbine which it serves. A 4-in. pipe line was installed from the steam header to the steam chamber of the condenser, and in this pipe line the flow nozzle was inserted with proper regard to correct conditions for accurate operation. The flow of steam was controlled by a throttle valve in the pipe between the flow nozzle and the condenser. The hotwell pump was disconnected from the hotwell and a pipe installed so as to conduct the condensate to an ordinary condensation meter. The discharge from this meter was then caught in buckets and weighed on a platform scale.

The circulating pump was then started and allowed to run for an hour, both before and after the test, to determine the amount of condenser leakage. The vacuum pump was not used. The throttle valve controlling the steam was then opened and adjusted to give the desired flow, and after conditions had become constant the test started, reading steam pressure and temperature at the nozzle, flow-meter, condensation meter, and weight of water caught in the buckets. The height of

water in the hotwell was made the same at the start and the finish, by noting the gage glass.

Two one-hour tests were conducted, and the steam-flow meter (mercury deflection, steam pressure and temperature) read every five minutes. The results were as follows:

	Flow-Meter Lb.	Cond. Meter Lb.	Weighed Water Lb.
Test No. 1	2,500	2,441	2,480
Test No. 2	2,540	2,461	2,590

These two tests showed that, allowing for personal and other errors, this particular flow nozzle is practically 100 per cent. accurate—much more so than necessary for the purpose for which the meter was being used.

L. E. BROWN.

Springfield, Ohio.

Operating Records for Small Power Plants

There has been much published recently about power plant records. In Fig. 1 and 2 are shown an operating engineer's report and the coal record of a small plant. In my opinion records of this kind are valuable assets to any plant, as they record the numerous details connected with the operation of the plant and afford a means of locating neglect in any department. I have also found that they create a co-operation that is of benefit in obtaining devices or equipment for the improvement of both service and working conditions. In my own case they helped me to obtain an output watt-hour meter for the pumping machinery and a flow-meter for the outgoing water, and it is now possible to make a fairly complete record.

City Water, Light and Power Plant

WATCH ENGINEER'S REPORT

FROM 6:00 A. M. TO 6:00 A. M.

Date May 6th, 1923

Units 5 DURATION OF RUN 24 Hours

TIME	7	8	9	10	11	12	1	2	3	4	5	6
Engine No. 1	O											O
Engine No. 2	X											X
PUMPS												
Pump No. 1	O											O
Pump No. 2	X											X
Pump No. 3	O											O
BOILERS												
Boiler No. 1	X											X
Boiler No. 2	X											X
Boiler No. 3	O											O
BOILER FEED PUMPS												
Pump No. 1	X											X
Pump No. 2	O											O
AIR COMPRESSORS—DAY												
Pump No. 1, Motor	O		X						4 5			O
Pump No. 2, Steam	O											O
AIR COMPRESSORS—NIGHT												
Pump No. 1, Motor	O				X					X		O
Pump No. 2, Steam	O											O
CARS COAL RECEIVED												

G. L. Brock Engineer.

A. C. Meter Read K. W. H.	4,000,004,680
Water Meter Reads	109,786
Feed Water Meter Reads	17,604,000
Out-put K. W. H.	8,290
K. W. Hours for Pumping	270
Gals. Water Consumed	3,190
Gallons Water Pumped	317,385
Pounds Coal Consumed	14,975
Kind of Coal	Blocton Minerun

	DAY	NIGHT
Peak Load Amp.	50, 54, 52,	52, 46, 48,
Average Boiler Pressure	130	
Average Temp. Feed Water	208	
Temp. Engine Room	92	
Street Lights on	1,35 A. M. Off	4,00 A. M.
White Way on	7,15 P. M. Off	11,00 P. M.
Fire Alarm in	No Out	
Weather	FAIR A. M. CLOUDY	RAIN P. M.

OILS AND SUPPLIES

Engine Oil	2 Qts.	2 QTS.
Cylinder Oil		6 "
Air Comp. Oil		
Dynamo Oil		
Grease		
Waste		½ Lb.
Packing		

Remarks

(Cylinder Oil Getting Low)

Fred Burgin

Assistant Engineer

FIG. 1. THIS REPORT SHOWS DETAILS OF OPERATION

City Water, Light & Power Plant

COAL RECORD

For 24 Hours Beginning 6:00 A. M. MAY 6th, 1922.

Gross 18,575

Deduct 3,600

Net 14,975

Boiler No. 1		Boiler No. 2		Boiler No.	
525		500			
500		500			
520		530			
530		540			
500	5	520	5		
500		500			
520		520			
525		530			
530		500			
540	10	510	10		
9310	18	9365	18		

FIG. 2. DAILY COAL RECORD

I am not a theoretical engineer and neither do I recommend a lot of complications for the plant, but I am a firm believer in "keeping a record" as well as having instruments for measuring the amount of product, cost, etc. I visited a neighboring plant not long ago and the engineer was telling me how economical his plant was on fuel, when I finally discovered he didn't have scales to weigh the coal or any instrument to measure the current consumption or the quantity of water pumped, so his claim of economy was only a guess.

G. L. BROCK.

West Point, Miss.

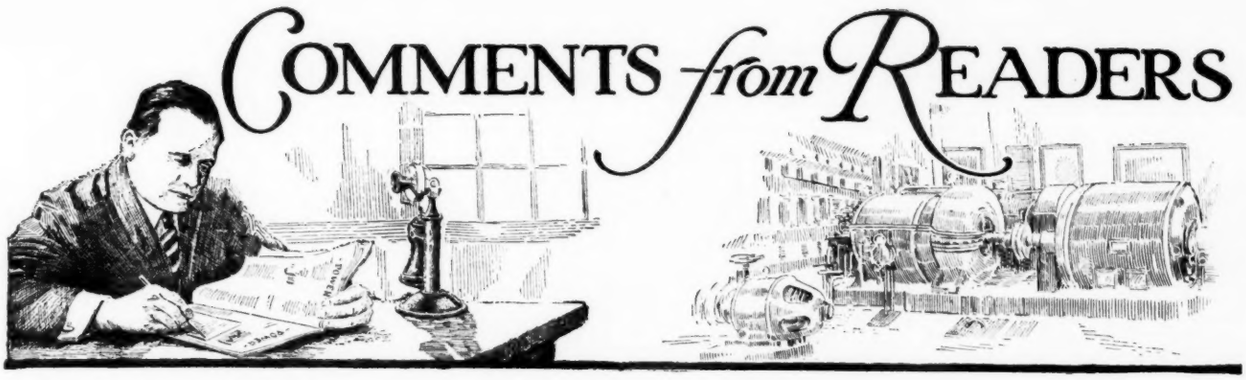
Change in Piping Eliminates Plugging of Blow-Off Pipes

The plugging of blow-off pipes gave me considerable trouble when I first took over my present plant, the deposits appearing to build up from the bottom of the 90-deg. elbow, and not from the blow-down valve itself. To eliminate this condition, I decided to change the piping and replace the 90-deg. elbow with a long radius bend. This was done on all the boilers, and during the last two years no further trouble has been experienced with plugged blow-down pipes.

F. P. MATTHEWS.

Dryden, Ont., Canada.

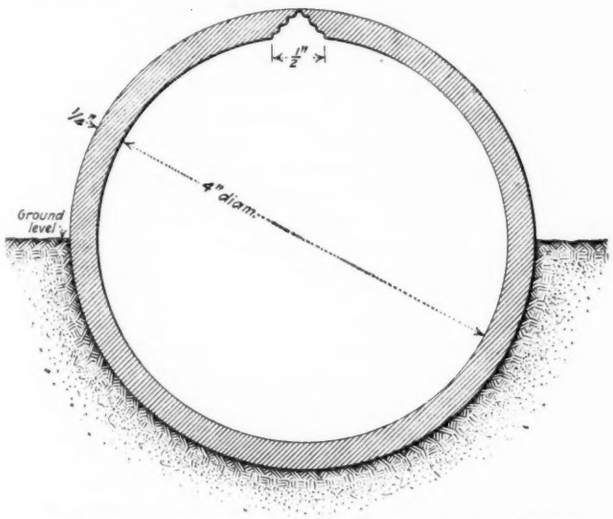
One system for removing liquid from the separator in the refrigerating plant has the drain line connected to an automatic drip tank and pump which is operated with a float and returns the liquid to the expansion or evaporating coils, the operation being the same as that used in a steam plant for returning condensate to the steam boiler.



Corrosion Due to Galvanic Effect

In the May 16 issue there was a description of the failures of two different lines of pipe, both situated in hot countries. The hypothesis is advanced that the cause was electrolytic action between particles situated in the highest point of the pipe—where the corrosion occurred—and portions of the pipe that were electronegative, and that the difference in the potential of the points was due to thermocouples caused by the variation in temperature between the top of the pipe, which was exposed to the rays of the sun, and other portions more or less buried in the earth.

While there is probably no question that the effect described was due to galvanic action, for I believe that



CORROSION OF WROUGHT-IRON PIPE CAUSED BY GALVANIC ACTION

practically all, if not entirely all, of the corrosion usually ascribed merely to rust is due to electrolysis between small particles of dissimilar metals combined in the steel or iron of which the structure is made, it is doubtful if there would be enough difference in temperature between different parts of the circumference of a small pipe filled with water to form thermocouples of sufficient voltage to cause electrolytic deposition and, if there were, that the points of pitting would always be in a straight line at the exact top of the pipe. Would it not be more likely that the water in the pipe, perhaps carrying traces of acid, caused the corrosion and that the action was greater at the top of the pipe because there any entrained air would collect, and therefore there would be quicker rusting than where the pipe was always under water? The points where there are particles of free carbon would be where the pitting would occur, and this would explain why the pipe would fail at points rather than all along the line.

While it was said that the recurrence of the trouble was prevented by burying the pipe, that is something time alone could prove, and it may be that not sufficient time had elapsed to verify the statement that the covering was a cure for the condition.

Westfield, N. J. G. H. McKELWAY.

Comparative Tests on Coal and Oil

The comments of Thomas F. Walsh appearing in the July 4 number, in reference to "Comparative Tests on Coal and Oil Burning Boilers," question the large difference in efficiency between the coal-burning boiler and the oil-burning boiler, the figures as given being 52.6 per cent for coal and 71.5 per cent for oil.

The answer to this is found in the difficulty experienced in keeping the coal-burning boiler operating continually under best conditions, owing to the necessity of frequently changing the draft to meet sudden fluctuations of load. These fluctuations could be more successfully met with the oil-burning boiler because of the ease with which it was possible to control the rate of combustion of fuel and to do so without sacrifice of efficiency.

From the data presented, especially from the flue-gas analysis, it would seem difficult to account for so low an efficiency as 52.6 per cent. On the other hand, it is not unreasonable to expect an efficiency of this order in a 100-hp. horizontal return-tubular boiler, hand-fired and operating at a widely fluctuating load. It is, of course, very difficult to obtain a flue-gas analysis that accurately represents the average conditions of combustion over a period of ten hours. The analysis given in each table was the average of a considerable number, but even so, much reliance cannot be placed upon it. Assuming, however, that 0.44 per cent is the correct figure for the *CO* content of the flue gases when coal is burned, the direct heat loss corresponding to this is only about 2 per cent; but the heat losses due to unconsumed hydrogen and hydrocarbons indicated by this percentage of *CO* were probably several times this amount. For example, tests reported by the United States Bureau of Mines, Bulletin 334, indicate a possible drop in boiler efficiency from approximately 70 per cent to approximately 57 per cent, with an increase of *CO* from 0.1 per cent to 0.4 per cent. The conclusion from the Bureau of Mines experiments is that the direct loss represented by the observed per-

centage of *CO* may be only one-third or less of the total drop in over-all boiler efficiency due to incomplete combustion losses which are indicated by, but not due directly, to the presence of *CO*.

The July 4 issue also contained a letter from D. F. Grahame on the same subject. Mr. Grahame believes that the figures for the cost of steam in cents per thousand pounds—namely, 55.7c. for coal and 52.1c. for oil—place the coal-burning plant in an unfavorable light as compared with the oil-burner, and therefore prefers to re-compute the results on the basis of conditions more nearly typical, taking the cost of coal to be $5 per ton instead of $8.25, and assuming an over-all boiler efficiency of 60 per cent in place of 52.6 per cent. On the basis of these assumptions he finds that the oil-fired plant is at a disadvantage and cannot compete economically with coal.

However, the original article reported results based on conditions actually existing rather than on hypothetical conditions. In the opinion of the writer the conditions found are by no means out of the ordinary. While the efficiency reported for the coal-burning boiler is considerably below the ideal, it is not far from the average under similar conditions. As to the costs of coal and oil, these vary widely with different localities, and naturally affect in a direct way the cost of steam, so that whatever be the original basis of computation, allowance must always be made for prices peculiar to a given locality. S. A. SMITH, JR.

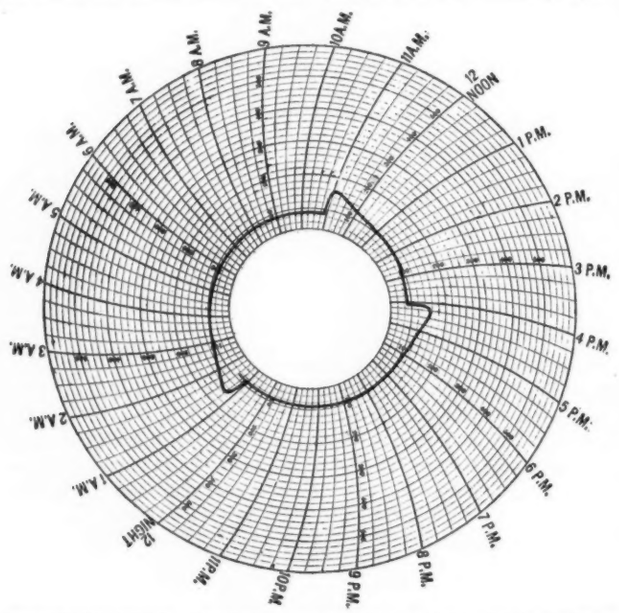
New Haven, Conn.

Boiler Blow-Down Recorder

In the May 16 issue an article by William Mader shows a chart from a recording pressure gage which he connected to the blow-down in order to record the regular blowing down of the boilers.

Undoubtedly most engineers who have charge of boilers have at some time been up against the same proposition as Mr. Mader, and while his idea is a good one and gives the necessary information, a recording thermometer installed for the same purpose has the advantage of not only telling the time and how often the boilers are blown down, but also indicating whether any of the valves are leaking. When a leak occurs, the pen does not fall below the 100-deg. line. The tube is wrapped on the outside of the blowoff pipe, and the rise in temperature is sufficient to indicate that the boilers have been blown down as shown by the chart. Since this instrument was attached, there has been no trouble with dirty boilers. H. WESTWOOD.

Lansing, Mich.



THERMOMETER RECORDS BLOWING DOWN OF BOILERS, ALSO LEAKY BLOW-DOWN VALVES

Why Do Piston Rings Break

I was much interested in reading in the June 6 issue the experience given by Mr. Collins respecting piston ring breakages.

During my experience I have many times come across similar trouble and have invariably traced the cause to the incorrect clearances of the piston. If the piston runs an excessive amount into the counterbore and the rings are of the narrow type, the ring as it leaves the walls of the cylinder may expand to the larger diameter and may be broken on the return stroke. From a similar cause the ring may be broken by striking a shoulder that has formed at the cylinder ends. The shoulder may be the result of the malalignment of the cylinder and crosshead guides. The piston may have become worn, consequently having a loose fit in the cylinder; the ring thus projects beyond the periphery of the piston, strikes the shoulder and sets up a knock which in time may cause a breakage of the ring.

In the writer's opinion the best plan to adopt when troubled with piston ring breakage is to check over the piston clearances, giving special attention to the length of the connecting rod. It may have happened that at some time repairs and adjustments have been made with the purpose of taking up the wear of the brasses without taking into consideration the length of the rod, which may become lengthened or shortened by the process.

Apart from altering the standard length of the piston rod it is in my opinion bad practice to weaken the rod end in the manner Mr. Collins describes.

If care is taken to keep the rod to its original length as near as possible, when adjusting the brasses, the clearances will remain unaltered and no shoulder will be formed, and the risk of piston ring breakage will be reduced to a minimum. THOMAS W. AIREY.

Gainsborough, Lincolnshire, England.

Size of Wire for Motor Circuits

In the article, "How to Compute a Complete Motor Installation," in the May 2 issue, in case No. 2, dealing with the 440-volt alternating-current motor started with an autostarter, it appears to me that Mr. Slack has made two mistakes. In the first place he states that No. 0 wire is necessary between the line cutout and autostarter; this should be No. 2 wire according to his table. In the second instance he says that a No. 4 wire would be sufficient between the autostarter and the motor, while according to my understanding the wire should be of the same size as that between the line cutout and the autostarter. The first mistake is on the safe side and was corrected in the June 20 issue on page 985.

I know of no section or paragraph in the National Electrical Code which would permit the use of a smaller

wire from the autostarter to the motor than from the line fuse to the autostarter. There seems to be no reason for a smaller size of wire between the autostarter and motor than between the line cutout and autostarter, and I do not think it should be permitted. During the starting period there are no fuses or circuit breaker in circuit between the line fuse and motor where standard equipment is used, therefore they afford no protection for the No. 4 wire.

When the relays are properly set, they should open the circuit when 125 per cent of the rated motor current passes through their coils. In many cases as with the 50-deg. motors, they should open the circuit when 110 per cent of the rated motor current passes through the relay coils. Therefore, the No. 4 wire would be protected only while the motor is connected in the running position through the oil switch. In the starting position the excessive current is allowed, which is the real cause for the increase in the size of wire over that which would carry 125 per cent of the rated motor current safely.

I feel that Mr. Slack has rendered a valuable service in publishing his table, and therefore I only wish to make constructive criticism in the mildest form.

New York City. JOHN B. WEIBLE.

[Mr. Weible's letter was submitted to Mr. Edgar P. Slack and the following is his reply.—Editor.]

Further careful study and discussion with the committee of the National Fire Protection Association who drafted the motor protection rules of the National Electrical Code confirm the original opinion that No. 4 wire is all the Code requires between the autostarter and motor in case No. 2 in my article appearing in the May 2 issue.

The principal rule bearing on this subject is part of Rule 8-c-3, as follows "To provide for the large starting currents of certain types of A.-C. motors without overfusing the conductors, wires considerably larger than 110 per cent of the motor name-plate current rating may be necessary in that part of the circuit not included in the protection afforded by the motor protective device," indicating that these larger wires are not necessary in the other parts of the circuit.

The overload coils of the autostarter, as pointed out, are out of circuit during starting, this being permitted in Rule 8-c-1; and it is also true that during this period the circuit from the autostarter to the motor is called on to carry the heavy starting current, which may be anywhere from twice to four times full-load current, depending upon the voltage taps used on the autostarter. Nevertheless, while the motor is running, this part of the circuit is fully protected by the overload trip coils, and additional protection during starting is not considered necessary because of the short duration of starting, the infrequency of starting, and the fact that the operator would be quickly aware of any trouble and by simply releasing the handle could disconnect the motor and the circuit between the autostarter and the motor from the line.

The computation for this part of the circuit would be as follows: Set time-limit overload trip coils at 125 per cent of motor rating; for wire size between autostarter and motor take 110 per cent of motor rating and choose wire having at least this capacity from Table A of Rule 18. If fuses were used at the autostarter instead of overload trip coils, the fuses might be as large as 125 per cent of the motor rating, and in this case it would be necessary to have the capacity of the wire as large as the rating of the fuse.

While for case No. 2 in question, a No. 4 wire is all that the Code requires, there are no objections to the use of a larger wire. Many wiremen prefer to use wire of the same size between the autostarter and motor as between the line and autostarter, as the protection is somewhat improved and it is unnecessary to bother with two sizes of wire. EDGAR P. SLACK,

New York City. Assistant Engineer, Underwriters Laboratories.

Cost of Leaky Blowoff Valves

We were interested in the article on "Blow-off Valves and Connections," by W. H. Wakeman, which appeared in the June 20 issue. In this article attention is called to an exaggeration of the cost of leaky blowoff.

For the last fourteen years we have been manufacturers of one of the well-known plunger blowoff valves, which are in general use in stations throughout the country. During these years we have tried not to exaggerate the cost of leaky blowoff valves, but have endeavored to present fairly the real facts in the matter.

The illustration here shown gives information that we believe is authentic. It shows the cost of leaky blowoff valves where the size of the leak varies from zero up to a hole of ⅜ in. diameter. This diagram we have used in our blowoff-valve catalog, and have given the following facts in connection with it.

Considering the blowoff-valve question from a dollars and cents point of view, we are confronted with the fact that even slight leakages are often the means of wasting hundreds of dollars of coal and water annually.

The chart clearly shows the loss through different-sized leaks running at 150 lb. pressure with coal at $2 per ton.

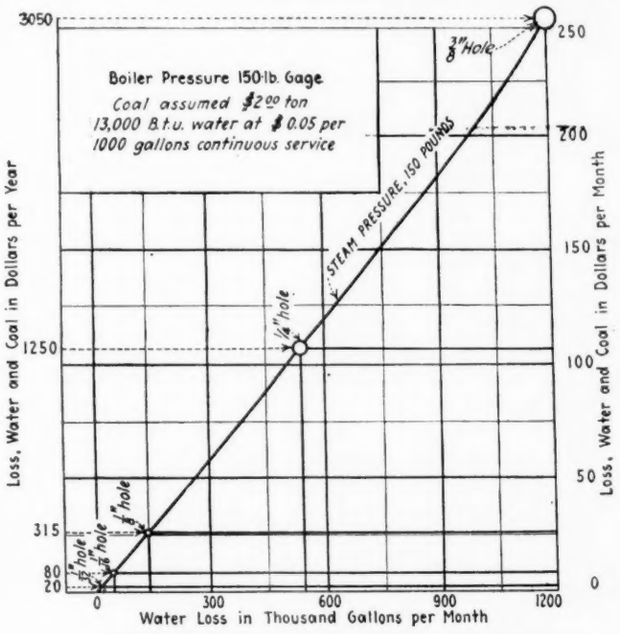


CHART SHOWS COST OF LEAKY VALVES

When it is considered that today coal costs from $5 to $10 per ton, it will be seen that the figures here represented are very conservative.

Coal costs money, no matter how much, and for every pound of steam wasted through blowoff leakage there is a certain definite sum of money being wasted. All this might be saved by the use of tight blowoff valves.

Philadelphia, Pa. D. R. YARNALL, Yarnall-Waring Co.

QUESTIONS AND ANSWERS

Overspeed and Underspeed of Motors

We have two alternating-current 60-cycle 2,300-volt generators driven by separate Diesel engines. Induction motors connected to one generator show overspeed, while those connected to the other generator run considerably below speed, both voltages being normal. Please advise the cause of trouble. E. J. B.

If the two alternators are operating separately, so that each has its own load, and there is no connection between, probably the engine driving the generator that is connected to the slow motors is running slow.

It is suggested that you take the speed of this generator shaft, which should be the same as the name-plate rating of the machine when at no load, and 2 or 3 per cent below the name-plate speed when the generator is at full load, and also check the speed of the other engine in the same manner and adjust the governors to give proper no-load and full-load speeds.

If the two alternators are in multiple, so they are both connected to the same busbars, the trouble would not lie in the engines, as long as the machines divide the load properly. In the latter case the trouble would probably lie in overloading the motors or some mistake in measuring the speed.

Installing Alternating-Current Circuits

Why is it necessary to put all wires of the same circuit in a single conduit when installing alternating-current wiring? G. C.

There are three reasons; namely, to prevent heating of the conduit, to prevent high inductive voltages being produced in the circuit and for safety. If only one wire is in an iron conduit the alternating magnetic field set up about this conductor will induce a voltage in the conduit, which, if two points on the conduit are connected together to complete a circuit, will cause a current to flow. This current may be sufficient to heat the conduit seriously and may even cause a fire hazard.

On account of the conductor being surrounded by iron, the magnetic field set up by the current will be many times that if the conductor was in open air. This increase in the magnetic field will increase the induced voltage in the conductor, causing not only a greater voltage drop in the line, but also a lower power factor than if the conductor were not surrounded by iron. When the two conductors of a single-phase circuit are placed in the same conduit the current in the two wires will have opposite directions and the effects of one will neutralize the other. In a three-phase circuit the three wires must be put into the same conduit, likewise for a three-wire two-phase circuit. In a four-wire two-phase circuit the two wires of each phase may be put into the same conduit or the four wires of the two phases. One wire of each phase must not be put into a separate conduit since the current in these wires will be 90 deg. out of phase and will not neutralize their inductive effects.

A "Catch Question" (?)

The following question was asked at an examination. I would like to know if it is a "catch question" and, if not, what is the answer and explanation:

What pressure per square inch is required to lift a cubic foot of water through a 6-in. pipe, a height of 250 ft.? S. G.

The query may be regarded as a "catch question" from introduction of the height to which the water is to be raised because, neglecting the elements of time and friction, no more pressure would be required under the water to raise it 250 ft. than any other height.

The weight of a cubic foot of water at the standard temperature of 62 deg. F. is 62.355 lb. When contained in a vertical 6-in. dia. pipe, the water would be in the form of a plug 6 in. in diameter, and the end of the plug would have an area of $6 \times 6 \times 0.7854 =$ 28.274 sq.in. Hence at the base of the plug the weight of the water would exert a pressure of $62.355 \div 28.274 = 2.205$ lb. per sq.in. Therefore the plug of water could be sustained by a gas, liquid or solid that exerted the same pressure, and, neglecting friction, the plug would be raised 250 ft. or any other height with persistance of any pressure on the under side in excess of 2.205 lb. per sq.in. gage pressure, or pressure above the pressure of the atmosphere.

Steam Bound Feed Pump

How can the water end of a boiler feed pump be prevented from becoming steam bound? M. W. A.

A feed pump may become steam bound from hot water of the boiler being forced back through the pump to the suction from leaky boiler-feed check or stop valves and leaky pump piston and valves. The trouble from that cause is not likely to be serious if the boiler-feed line stop valve is shut down hard when the pump is not in use, and if the pump when in operation is run fast enough to overcome the leakage. When pumping hot water, the pump may become steam bound, because the suction head is not great enough for filling the pump chamber without reduction of pressure below the boiling point of the water corresponding to its temperature. The reduction of pressure that results from friction of flow to the pump will be reduced by

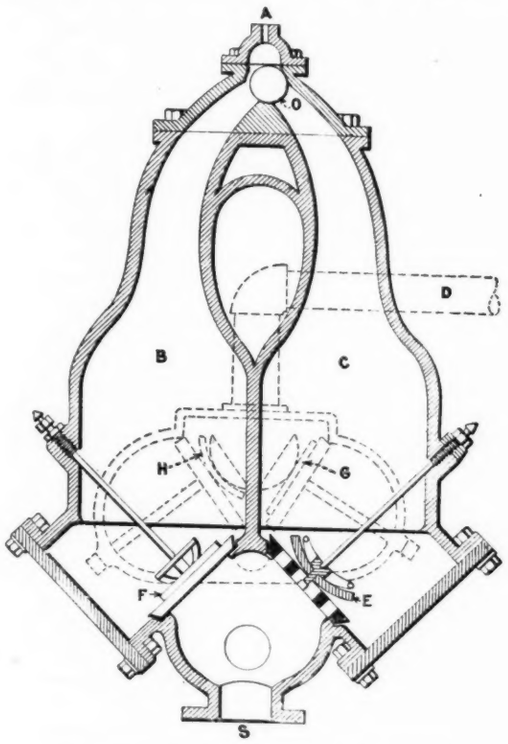
running the pump slower. If that is not practicable, the suction water must be supplied to the pump under a greater head, i.e., by lowering the pump or raising the level of the suction water.

The loss of suction head will be greater, the smaller the size and greater the length of the suction line. Unless the suction water is supplied under head and the suction line is short and of full size of the inlet provided on the pump, trouble is likely to be experienced in pumping water warmer than about 150 deg. F. and about one foot additional head will be required for each 5 degrees higher temperature of the suction water.

Operation of Pulsometer Pump

What is the method of operation of a pulsometer pump? R. L. A.

The illustration is a vertical sectional view showing the principal features of a pulsometer pump. The operating steam comes in contact with the water and the pulsometer is in reality a development of the Savery engine. The suction connection is at *S*. The suction valves are shown at *E* and *F*. The discharge valves, *G* and *H*, and discharge chamber connected with the discharge pipe *D*, are shown in dotted lines. Steam is admitted at *A*, and if the ball valve is resting over the right-hand opening, steam will enter the space *B* and drive out the water through the discharge valve *H*.

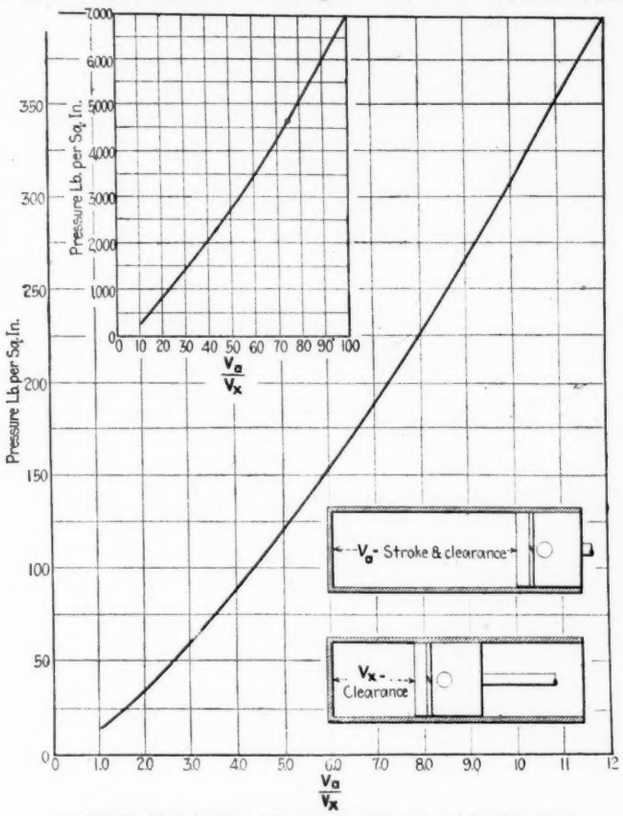


VERTICAL SECTION OF PULSOMETER

When the water surface reaches the level of the discharge valve, the sudden reduction of pressure in *B* causes the ball valve to close off steam from *B*, and then the condensation of the steam on that side draws water through the suction valve while steam is being admitted to the side *C*. The illustration shows steam cut off by the ball valve *O* from the space *C* with the suction valve *E* open and discharge valve *G* closed for the operation of filling *C* while *B* is being emptied through the discharge valve *H* to the discharge chamber and discharge connection *D*. By thus filling one lobe while the other is being emptied, the discharge at *D* is made continuous.

Compression Pressures in Gas Engine

How can one figure the pressure in the cylinder of a gas engine having a plain combustion chamber? In other words, assume the engine is of the four-stroke cycle and the stroke is 9 inches, what pressure will be inside the cylinder when the distance between the head and piston is ¼ inch? B. G.



COMPRESSION TEMPERATURES IN GAS ENGINE

The pressure may be calculated by the formula

$$\frac{P_x}{P_a} = \left(\frac{V_a}{V_x}\right)^{1.35}$$

where P_x = Pressure at end of compression stroke,
P_a = Pressure at beginning of compression stroke,
V_a = Total cylinder length, or stroke + clearance,
V_x = Clearance length.

In the chart is shown a curve giving the pressure for any ratio of $\frac{V_a}{V_x}$, assuming the pressure at the beginning of the stroke is 14 lb. absolute (—1 lb. gage). In your problem $V_a = 9 + \frac{1}{4} = 9.125$ inches and $V_x = \frac{1}{4}$ or 0.125 inch. The ration is then 9.125 ÷ 0.125 = 74.6. The curve shows that for this ratio the final pressure will be 4,700 lb. No workable engine can employ such compression pressures.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses.]

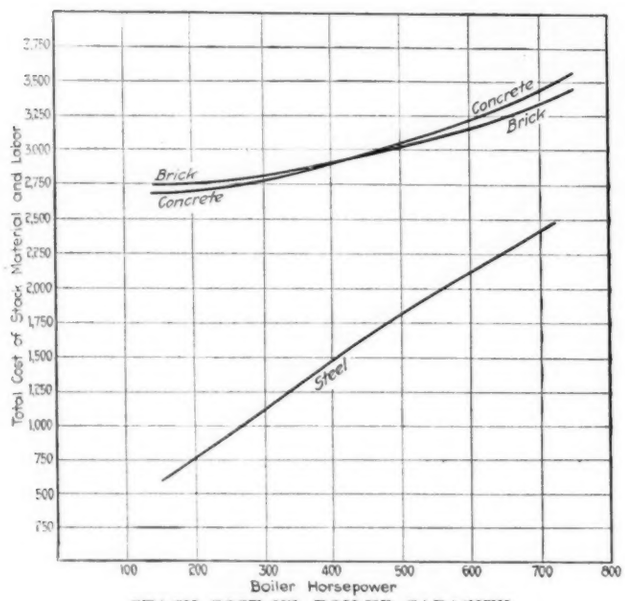
Relative Cost of Steel, Concrete and Brick Stacks*

The following data cover the cost of stacks complete, including material and labor, and are based on the costs prevalent March, 1922:

Size of Stack Dia. at Top	Height	Boiler H.P. (10 Sq.Ft. H.S.)	Total Cost	Cost per B. H.P. (10 Sq.Ft. H.S.)	Maintenance and Depreciation per Year
STEEL STACKS					
34 in.	85 ft.	150	$569.00	3.79	$91.00
36 in.	75 ft.	150	600.00	4.00	96.00
38 in.	90 ft.	200	758.00	3.79	121.00
34 in.	85 ft.	300	1,138.00	3.80	182.08
BRICK STACKS					
42 in.	100 ft.	200	$2,900.00	14.50	$87.00
Not furnished		200	2,600.00	13.00	78.00
Average		200	2,750.00	13.75	82.50
54 in.	100 ft.	400	3,100.00	7.75	93.00
Not furnished		400	2,800.00	7.00	84.00
Average		400	2,950.00	7.37	88.50
66 in.	100 ft.	600	3,300.00	5.50	99.00
Not furnished		600	3,000.00	5.00	90.00
Average		600	3,150.00	5.25	94.50
REINFORCED CONCRETE STACKS					
42 in.	70 ft.	200	$1,675.00	8.37	$41.87
42 in.	100 ft.	200	3,000.00	15.00	75.00
Not furnished		200	2,800.00	14.00	70.00
Average		200	2,492.00	12.45	62.29
54 in.	106½ ft.	400	2,450.00	6.12	61.25
54 in.	100 ft.	400	3,200.00	8.00	80.00
Not furnished		400	3,000.00	7.50	75.00
Average		400	2,883.00	7.20	72.08
60 in.	129½ ft.	600	3,100.00	5.16	77.50
66 in.	100 ft.	600	3,400.00	5.66	85.00
Not furnished		600	3,200.00	5.33	80.00
Average		600	3,233.00	5.38	80.83

The accompanying curves represent the average total cost taken from a number of steel, concrete and brick stack costs. While no allowance is made for a small variation in diameter and height of stack for plants of the same boiler horsepower, the result represents a fair comparison in the cost of stacks.

These curves show that steel stacks increase in cost directly in proportion to the boiler capacity of the plant, this being due to duplication of stacks for the larger plants,



STACK COST VS. BOILER CAPACITY

the cost being much lower for small plants, but gradually approaching the cost of concrete and brick as the size of plant increases.

Concrete stacks decrease in cost per unit of boiler capacity as the size of the plant increases, the cost being just slightly higher than the cost of brick for the same size of plant above 5,000 sq.ft. of heating surface, and less for plants below that size.

Brick stacks decrease in cost per unit of boiler capacity as the size of the plant increases, the same as for concrete stacks, only not in the same proportion, the decrease being greater, the cost of same being slightly less than the cost of concrete for the same size plant above 5,000 sq.ft. of heating surface and more when below that size.

Maintenance and depreciation average 2½ per cent of total cost for concrete stacks per year, 3 per cent for brick stacks and 16 per cent for steel stacks. This, however, may be variable, depending upon local conditions, design and proper maintenance, but appears to represent a basis of comparison which is comparatively accurate.

*Excerpt from report of Committee on Modernization of Stationary Boiler Plants, American Railway Association.

Boiler-Plant Efficiency in England

(By our London Correspondent)

There has just been published a reprint of a series of articles on "Coal Saving by Modern Methods of Steam Generation," from the *Textile Manufacturer* (August-December, 1921, and January-March, 1922). These articles were written by David Brownlie, of Manchester, England, and give complete detailed figures for the performance of sixty-five different boiler plants in the dyeing, bleaching calico-printing, finishing, and dyeing and cleaning industries in Great Britain. Each test is of the most comprehensive character, being of one day's duration and also one week as a check test, and most elaborate precautions were taken in the way of feed-water measurement, fuel analysis with the oxygen bomb calorimeter, the use of combustion recorders in addition to hand methods of flue-gas analysis, pyrometers, draught gages, the determination of the steam used by nozzles and the power taken by mechanical stokers, etc. Also these tests represent the actual working figures of the plants week in and week out all the year around and are not special "test" figures carried out under abnormal circumstances.

The sizes of the plants varied from thirteen Lancashire (cylindrical) boilers with an annual coal bill of 12,000 tons per annum down to one Lancashire boiler with 950 tons, and the total consumption of the sixty-five plants was 275,637 tons per annum. Forty-six of the plants were hand-fired and nineteen mechanically fired, fourteen being sprinkling stokers and five coking. The coal burned averaged 11,950 B.t.u. per lb., 10.5 per cent ash, and an equivalent of 21.71 lb. per square foot of grate area per hour. The evaporation was 5,048 lb. per boiler per hour, which, allowing for the different sizes of the boilers tested, corresponds to 7,570 lb. per hour for a standard large-sized Lancashire boiler 30 ft. by 8 ft. Twenty-six of the plants were troubled with scale and the average hardness of the water was about 12 grains per gallon, but individual plants were higher.

Forty-eight of the plants had economizers, and these plants were thus saving 11.12 per cent of the coal bill. Thirty-three plants had natural draft, twenty-three employed steam jets, and nine had mechanical induced draft. The average CO_2 figures were 7.8 per cent, divided as follows:

Amount of CO_2	No. of Plants	Per Cent of Plants
1. Very good, over 12 per cent	4	6.1
2. Good, 10-12 per cent	5	7.7
3. Medium, 8-10 per cent	18	27.7
4. Poor, 5-8 per cent	33	50.8
5. Very bad, under 5 per cent	5	7.7

That is to say, over half the plants were below 8 per cent CO_2. The black-smoke figures were not good, nineteen being smokeless, eleven fairly good, twenty-eight medium, and 7 very bad.

Only twelve out of the sixty-five plants had superheaters and of these only three or four were fully equipped.

The average boiler efficiency of all the plants was 61.4 per cent. The figures are divided as follows:

Boiler Efficiency	Number of Plants
Over 80 per cent	1
75-80 per cent	0
70-75 per cent	4
65-70 per cent	12
60-65 per cent	14
55-60 per cent	12
50-55 per cent	16
Less than 50 per cent	6

Mr. Brownlie published previously the results in various other industries. Thus, 100 colliery boiler plants showed 55.5 per cent net boiler efficiency, sixty chemical works 57.9 per cent, and two hundred fifty plants in forty-one industries, 60.09 per cent. Mr. Brownlie's latest figures include four hundred different boiler plants in over fifty industries in Great Britain with a total annual coal bill of over 3,500,000 tons per annum, and the average working boiler efficiency is about 58 per cent. That is to say, in Great Britain, burning 90,000,000 tons of coal per annum for steam generation, over 20 per cent of the coal bill, that is 20,000,000 tons per annum, is wasted because of out-of-date methods.

According to Mr. Brownlie the defects may be grouped into two main classes, the first of which is inferior equipment. The grate area in general is too long, and not enough coal is burned per square foot of grate area per hour. The evaporation is too low, the draft defective and the CO_2 figures poor. Full advantage is not taken of economizers. In Great Britain about 75 per cent of the plants are equipped with economizers and the average saving in the coal bill for the whole country is only about 7½ per cent. In this respect, however, Great Britain is much better than the United States, where economizers are very largely neglected. Also, superheaters are hardly used at all in Great Britain, the average saving from their use being less than 1 per cent of the coal bill; and here American plants are undoubtedly superior. Furthermore, in many of the plants the brickwork is leaky, the methods of firing defective, and at least 5 per cent of the steam produced is wasted in steam jets.

A More Important Cause of Waste

The second general cause, even more important than the first, is that the plants, in general, lack proper supervision and do not employ adequate records. Mr. Brownlie gives it as his opinion, based on the personal inspection of over 2,000 British boiler plants, that 99 per cent of them have no steam meters, 95 per cent no CO_2 recorders, and 90 per cent no feed-water meters, and not 5 per cent keep a proper weekly log of the performance, without which it is impossible to obtain the best results.

Some Results of Turbine Practice in England

The following tables are from a paper by D. H. Selby-Bigge (London), presented at the May meeting of the Iron and Steel Institute of England. Table I gives results obtained from Metropolitan-Vickers steam turbines under actual working conditions. Table II shows what may be expected in Fraser-Chalmers Rateau type turbines at higher pressures and temperatures, the author stating that it remains to be seen if maintenance costs justify these steam conditions.

TABLE I

Type of Turbine	Size in Kw.	R.P.M.	Steam Pressure Lb. per Sq.In. Gage	Superheat Deg. F.	Vacuum in. Hg.	Test Load in Kw.	Actual Consumption Lb. per Kw. Hr.
High pressure	5,000	3,000	170	125	28.5	5,473	13.4
High pressure	5,000	3,000	190	100	28.5	5,500	13.35
High pressure	3,000	3,000	180	200	28.5	3,000	12.57
High pressure	3,000	3,000	160	129	27.5	2,992	14.38
High pressure	2,000	3,000	160	160	28.0	2,015	13.9
Mixed pressure	1,500	3,000 H.P.	160	150	28.1	1,450	15.4
Mixed pressure		L.P.	1	dry	27.5	.....	.....
Mixed pressure	1,000	2,500 H.P.	150	150	27.85	991	16.1
		L.P.	1		27.75	680	32.0

TABLE II

Ref.	Type of Turbine	Size in Kw.	Speed R.P.M.	Steam Pressure in Lb. per Sq. In.	Total Temp., Deg. F.	Vac. at 30-in. Bar., in. Hg.	Steam Consumption Lb. per Hour
A	H.P.	5,000	3,000	300	700	28½	10.35
B	H.P.	3,000	3,000	300	700	28½	10.7
C	H.P.	1,000	6,000	250	650	28½	12.1 geared

Thickness of Shell in Return-Tubular Boilers

By E. C. Fisher*

The A.S.M.E. Boiler Code Committee meeting in June, 1921, recommended a definite limitation in the thickness of return-tubular boiler shells; it developed that such a limit had already been imposed, in an unexpected manner, after a discussion by the manufacturers of the Boiler Code Rules, where joints were so specified that a shell thickness of approximately $\frac{57}{64}$ in. could not be exceeded under the existing rules.

This conclusion was definitely reached at the Winter meeting in Pittsburgh, Pa. Girth seams or transverse joints are not allowed more than ½-in. shell thickness, while at the same time they must not fall below a certain proportion of the strength of longitudinal seams, which employ the full thickness of the boiler shell. As the thickness of shell is increased, the latter joints become stronger, but the former are limited to one-half an inch thickness and consequently reach a point where they are too weak to meet the relative requirements, and it becomes impossible to use such a shell under the rules.

It is well known that the resistance of a boiler shell to rupture in a transverse section is double the resistance longitudinally. Therefore, since the allowed pressure on a shell is based on the efficiency of the longitudinal joint for a given plate thickness, the efficiency of the circumferential joint must be 50 per cent of the efficiency of the longitudinal joint based on the *same thickness*. Owing to the staying power of the tubes and through braces the Code requires the efficiency to be only 35 per cent instead of 50 per cent of that in the longitudinal joint. Paragraph

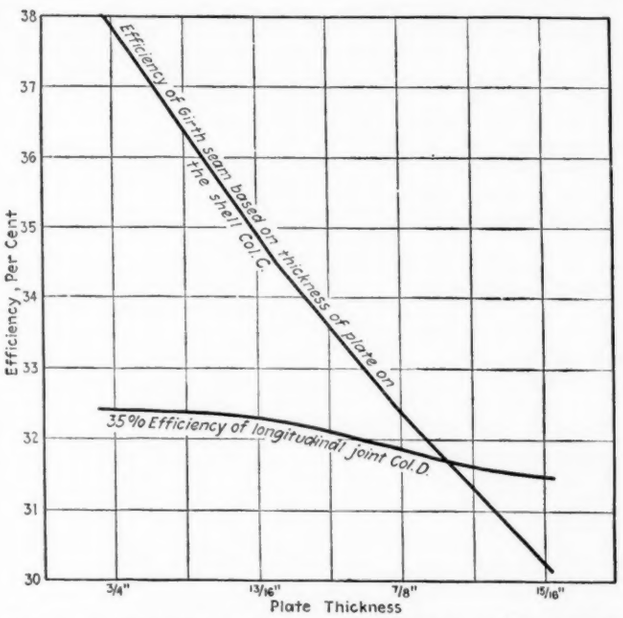


FIG. 1. SHOWS GIRTH SEAM EFFICIENCY FALLING BELOW REQUIREMENTS AT APPROXIMATELY 57/64 IN. THICKNESS OF BOILER SHELL

184c also requires that in circumferential joints exposed to the products of combustion the shearing strength of rivets shall be not less than 50 per cent of the full strength of plate, corresponding to the *thickness of the joint*. This paragraph was put in the Code as a detail of construction that would aid to eliminate fire cracks.

Bearing in mind now the relationship between the resistance to rupture in the longitudinal and circumferential

*Vice-president and general manager the Wickes Boiler Co. The study was presented to the American Boiler Manufacturers' Association, at its recent meeting at Shawnee.

joints, previously stated, as well as their comparative efficiencies, it is seen that there will be a point reached, as the plate thickness is increased, where failure takes place in the girth joint. The following is a table made up from a joint milled to ½-in. thickness, with 1-in. rivets in 1 1/16-in. holes at 2½-in pitch.

A	B	C	D
Thickness of Shell Plate	Efficiency of Longitudinal Joint Quadruple-Riveted	Efficiency of ½ In. Milled Girth Joint Based on Full Thickness of Plate in Shell	38 Per Cent of Longitudinal Joint in Column B
¾	92.7	37.8	32.4
13/16	92.3	34.9	32.3
⅞	91.2	32.4	31.9
29/32	90.5	31.3	31.6
15/16	90.1	30.25	31.5

The figures in column C were obtained by the following formula, the efficiency used being the lesser of values obtained using the two formulas. In this table the figures were not carried below ¾-in. plate because it is apparent that the efficiency stated in column C increases rapidly as thinner shell plates are used.

$$N = \frac{ss}{p \times T \times 55{,}000} \text{ or } \frac{(p-d) \times t \times 55{,}000}{p \times T \times 55{,}000}$$

E = Efficiency tabulated in column C;
ss = Shearing value of one rivet in single shear;
p = Pitch of rivets in girth joint, inches;
T = Thickness of plate in shell, inches;
d = Diameter of rivet, inches;
t = Thickness of plate at joint = 0.5 in. where shell is over 9/16 in. thick.

The curve Fig. 1 was prepared to show how the efficiency values shown in columns C and D approach one another

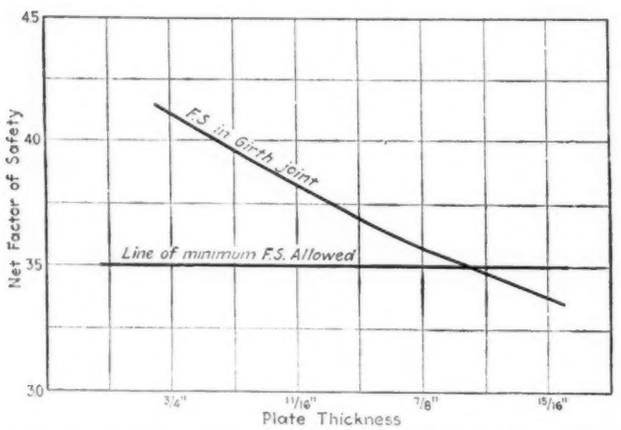


FIG. 2. FACTOR OF SAFETY OF GIRTH SEAM FALLS BELOW REQUIRED ALLOWANCE AT APPROXIMATELY 57/64 IN. THICKNESS OF SHELL

and cross at the point where the girth joint does not continue to meet the requirements of Paragraph 184b, in that the efficiency in column C becomes less than 35 per cent of the longitudinal joint efficiency as plate thicknesses increase. However, it should be pointed out that these curves will vary slightly, depending on the type of longitudinal joint selected and its efficiency.

Paragraph 185 of the Boiler Code requires that where the shell plate is thicker than 9/16-in. it must be milled to ½-in. As shown on the table and curve, the plates fail to comply with the requirements of Paragraph 184b when the plate thickness reaches approximately 57/64-in.

This problem can be approached from another angle. The longitudinal joint is based on a factor of safety of 5, and to be equally as strong, the girth-joint efficiency is required to be only 50 per cent that of the longitudinal joint. However, the Code, owing to the holding power of the tubes, allows the efficiency of the girth joint to be only 35 per cent instead of 50 per cent of that of the longitudinal joint. The factor of safety under these conditions can be obtained by direct proportion as 35:50::X:5, in which we find X=3.5. This is the minimum factor of safety on a girth joint to meet the Code requirements. While this is merely another way of stating the problem, it seems to me to be an aid toward a clearer understanding.

An objection to stating the problem in this manner is that it might be construed to mean that a part of the boiler is allowed a factor of safety of only 3.5, while by figuring the staying power of the tubes and braces it is actually over 5. However, it may be noted that every statement is qualified where 3.5 is a safety factor, by mentioning that it is due to the additional holding power of the tubes or stays.

The curve, Fig. 2, is plotted by assuming efficiencies of longitudinal joints as based on the foregoing table. The thickness of the plate in the shell determines the pressure allowable on the longitudinal joint. The upper curve on this plot, therefore, varies according to the thickness of the plate, as it affects the pressure and is also based on the strength of the circumferential joint with a plate thickness of ½-in. as required under Paragraph 185. It is important to note that this curve will also vary slightly with the type of longitudinal joint and its efficiency.

This plot shows that the maximum thickness is exactly the same as shown in the first curve, or approximately 57/64-in.

The conclusions are, therefore, that:

1. The A.S.M.E. Boiler Code in Paragraph 184b limits the thickness of plates in horizontal-tubular boilers.
2. This thickness, as shown by Mr. Barnum's table and the curves plotted, is approximately 57/64-in., depending on the character and efficiency of the longitudinal joint.
3. The factor of safety required in the circumferential joint is 3.5., neglecting the holding power of tubes and stays.

Again I wish to acknowledge with thanks the assistance and contribution to this paper by J. A. McKeown, L. B. Connelly, G. S. Barnum and G. Welter.

This paper is an attempt to report in condensed, organized form the result of a correspondence that has been carried on between J. A. McKeown, I. E. Connelly, G. S. Barnum, G. Welter of the Bigelow Company, and myself, since the Winter Meeting of the Association held at the Fort Pitt Hotel, Pittsburgh, Pa., Feb. 13, 1922. All these gentlemen have contributed in this correspondence the matter presented in this paper.

Powdered Fuel to be Used in Large Plant in St. Louis

The Union Electric Light and Power Co., subsidiary of the North American Co., has decided on the plans for a six-million-dollar power plant in St. Louis in which powdered fuel will be burned.

The reasons for this decision are not necessarily applicable to other large plants, but depend on quality and price of fuel, site of the plant, general layout, load factor and other conditions, so that each individual case must be worked out according to its own merits. Extensive tests and investigations on stoker equipment in comparison with pulverized fuel indicated to the designing engineers that the latter contains advantages under conditions obtaining at this plant.

The present plant is situated twenty miles from the center of the coal mining district, so that the fuel costs approximately two and a half dollars a ton and contains in the neighborhood of seventeen per cent ash; hence the decision to use powdered fuel is here of marked significance. One of the great advantages lies in the ability of the plant to utilize screenings and similar types of waste or cheap fuel, in event of a strike of miners.

Savings in operation, banking and pick-up losses, including the cost of ash disposal and operating payroll, as well as sustained furnace efficiency, favor powdered fuel.

The fixed charges it is estimated, in this case, will not exceed those of stokers. Pulverized fuel insures a uniform steaming capacity and can be handled with almost the facility of oil fuel.

The plant will be situated on the east bank of the river, where there are facilities for ash disposal and where dirt emitted from the stacks will not be objectionable. This location is nearer the center of load than the other bank

of the river, obviates bridge charges and makes it possible to connect with six railroads.

The initial installation will include eight B & W boilers of 18,000 sq.ft. of heating surface each, with one 30,000-kw. single-cylinder General Electric and also a Westinghouse unit of the same size. The plant will ultimately contain eight similar units. Steam will be supplied at 300 lb. absolute, 690 deg. at the throttle, the boilers being arranged for 350 lb. pressure. Economizers will not be installed.

An unusual feature will be the installation of the Lopulco System for powdered fuel, by the Combustion Engineering Corporation, in the boiler room; this is contrary to the usual practice of installing the powdered coal equipment in a separate building.

The plant is so designed that either stoker equipment or powdered fuel installation may be installed with equal facility in future additions.

The boilers are arranged in two rows with a receiving bin on the outside of each row. Coal passes from this bin through dryers using part of the stack gases and then to the pulverizers, from which it is conveyed to bins between the two rows of boilers. From this point chutes convey the powdered fuel to the furnaces.

Heat balance has not been completely laid out, but at the present it is expected to bleed the main units and in addition to utilize steam from a house turbine for adjusting the feed water temperature.

The condensers for two units will be installed in one pit, with twin intakes and a common discharge; both traveling and stationary screens will be used. The river level varies forty-five feet at this point, requiring a low condenser pit. Electrical auxiliaries will be used throughout.

McClelland & Junkersfeld, Inc., the consulting engineers and constructors in charge of this project, point out that improvements may be expected in the development of stokers as well as in pulverized fuel equipment, but that stokers have been under development for a long period of years and the burning of coal in pulverized form in large quantities by central stations has been done only in the last few years. Without attempting to estimate future developments in the two classes of equipment for burning coal, they state that at least the present relative position, so far as the Cahokia Station is concerned, will probably be maintained.

President's Proposal Accepted by Mine Operators, Rejected by Workers

Expressing accord with the President's desire to establish a commission for investigation of the coal industry and the drafting of temporary wage scales, the majority of the coal operators have accepted the President's proposal of July 10 without reservation or qualification. The United Mine Workers of America, on the other hand, have unanimously declined to consider arbitration of their problems, until such a commission as that described by the President shall have been created and its work of investigation brought to a successful conclusion.

Objections of the Operators

In the case of the operators, approval of the President's plan was by no means unanimous. Dissenting replies were submitted by the Pittsburgh Coal Producers Association, the Indiana operators, and the Central Coal Association of Pennsylvania. These operators contend that the determination of wage scales should be by districts, rather than by a universal scheme embracing the entire industry; they protest against the tacit recognition of the "check-off" system; under which dues for the United Mine Workers are collected from the pay envelopes of all union workers; they reject the President's temporary wage scale because it is based upon the inflated schedules of 1920, the highest wages ever paid in the industry; and, finally, they frown upon any proposed commission containing biased members of the coal industry, either workers or operators.

The remaining operators, while unreservedly voting for acceptance of the President's proposal, state that they believe it due the public and the industry that they should point out the difficulties of such unreserved acceptance, and suggest some further means of relieving the situation. Their attitude is stated in the following words:

Inasmuch as the old machinery for making scales based on the Central Competitive Fields has broken down, proven entirely inadequate to meet the changed economic conditions of the country, and is therefore now irretrievably abandoned; and inasmuch as the greatly varied technical and economic situation of the various districts makes it almost impossible for a national arbitration board to satisfy these differing situations; and inasmuch as the operators here assembled are anxious to maintain the principle of collective bargaining, we suggest that it should be made possible under a national arbitration for negotiations to be undertaken by states or other large groupings of districts, subject to the general direction of the Arbitration Commission of the major issues involved. This is in the mutual interests of both operators and workers, because of the many technicalities and varied economic conditions differing in the various sections of the country.

We welcome an exhaustive inquiry into the functioning of the industry, as we believe any exposure of the truth of the situation will show the intolerable and wasteful conditions under which the unionized industry is carried on under the present labor regime, and the penalties that are imposed upon the public by the inability to secure the enforcement of contracts and the thousand other ills. We suggest that it would be desirable to separate the problems of anthracite and bituminous coal. We see no objection to separating again the investigation problems from those of arbitration of the present disputes into different commissions, pending the development of some plan of stability.

Reasons for the Miners' Rejection

The mine workers base their refusal to consider the President's proposal on the belief that no attempt to determine just and reasonable rates of pay to workers in the coal mining industry can be successful until a searching investigation of the coal mining industry in all its phases, as recommended in President Harding's plan, is actually completed. Their opinion is given as follows:

Labor is only one factor in the production and distribution of coal. Labor costs are only one element in the many elements of costs involving the mining of coal and its transportation. All of these factors and elements are closely interrelated and interdependent. One factor, such as labor, cannot be segregated and a decision made upon it alone. Among other things, the relation of labor and other costs to profits and prices must be ascertained. Inquiry must also be made as to the degree of regularity of operation of the mines and the opportunity afforded to the mine worker, under prescribed rates of pay, to earn an adequate income for himself and his family.

By way of concrete illustration, it is stated, on the basis of the facts available, that the bituminous coal industry functions irregularly and intermittently because of overexpansion and unfair competition. Employees under existing rates of pay are unable to secure sufficient employment to earn living wages, while the public is compelled to bear excessive overhead charges amounting to approximately one dollar per ton on each ton of soft coal produced. Manifestly it is futile to attempt to adjust wage rates on an equitable basis until the truth of this condition of affairs has been thoroughly uncovered and the cause of it finally removed.

The naval appropriation bill for the year which began July 1 passed by Congress and approved by the President carries an appropriation for prizes in fuel consumption. It also allots $40,000 for power plant improvements at the Puget Sound, Washington, Navy Yard.

Construction work on the Waterside station of the Louisville Gas & Electric Company will be started immediately to make room for another 20,000-kva. unit. The demand for increased generating capacity is seen from the fact that the total connected load in 1914 was only 24,314 hp., whereas at the present time it is 64,046 hp., a gain of over 160 per cent. During the same period the number of customers increased 103 per cent. The kilowatt-hour-output for the year to date is running 17 per cent greater than that of last year. This has been caused by a net gain for the first five months of 1922 of 4,266 hp. of motor load and 1,651 kw. of lighting load.

News in the Field of Power

New England States Association, N.A.S.E., Holds Annual Meeting at Springfield

The annual convention of the New England States Association of the N. A. S. E. in conjunction with the mechanical exhibit of the New England Association of Commercial Engineers was held at Springfield, Mass., July 12, 13 and 14. The Bridgeway Hotel was the headquarters and was in close proximity to the auditorium, where the sessions of the delegates and the mechanical exhibit were held.

There were upwards of eighty delegates in attendance, representing nearly every state in New England. Many items of interest and importance to the organization were presented, discussed and harmoniously passed upon.

The subject that received the closest attention of the delegates was the report on the license law. Frank Guth, of the Cambridge Association, chairman of the Massachusetts State License Committee, elicited the commendation of the convention when he said that notwithstanding the influential opposition that had been brought to bear against the license law in the legislature during the past year, the engineers, by hard work and earnest endeavor, had succeeded in retaining their rights. He said it was the duty of every engineer in New England to use his best efforts to safeguard the Massachusetts State license law.

President Dudley K. Kimble complimented Mr. Guth and his committee, and said that the only way to secure safe and sure operation of power plants was through the licensing of engineers and firemen.

The reports showed that there has been an increase in the membership of twenty per cent during the last year, and it was hoped that this percentage would be largely increased in the next year by the intended campaign of advertising and missionary work.

Arthur F. Ford, chairman of the educational committee, was given credit for his work in that direction during the last season.

In order to obtain a larger delegation to conventions in the future it was agreed to elect one delegate to ten members, instead of one in twenty-five as heretofore.

At eight o'clock on Wednesday evening the exhibition was officially opened. Sandford C. Smith, president, was the presiding officer. After thanking the supplymen for their co-operation, and expressing his appreciation of the big attendance, he introduced Josiah Dearborn, city solicitor, representing Mayor Edwin F. Leonard. Mr. Dearborn said that he had inspected the various booths and was impressed by the many new inventions, and remarked that, though it may seem a tiresome task it was a duty that the engineer owed to society to keep abreast of such developments. Addresses were also made by Maj. James F. Myrick, Raymond T. Wilber and Henry H. Lynch.

On Thursday evening the opening exercises of the convention took place. Walter H. Damon, chairman of the local committee, presided. He introduced Mayor Leonard, who welcomed the convention to Springfield. He spoke of the dependence placed by the public upon the watchfulness and integrity of the engineer. He hoped that the National body would hold its convention in his city in the near future. Dudley G. Kimball, Thomas A. Ray and Raymond T. Wilber also made brief addresses. Mr. Damon was congratulated upon his efficient services in the arrangements of the convention. The necessary committees were then appointed and the meeting adjourned.

The mechanical display consisted of ninety-one booths, occupied by seventy-two exhibitors.

There was an enjoyable entertainment on Friday evening, which was free to the public. During the week there were shopping trips and auto rides for the ladies. The convention closed with a clambake at Riverside Park.

The engineers elected officers as follows: James Henderson, president, Boston; Elmer W. Perry, vice-president, Worcester; Freeman L. Tyler, secretary, Taunton; Walter H. Damon, treasurer, Springfield; Elmer A. Bassett, conductor, Bridgeport; Daniel Smith, doorkeeper, Manchester.

The officers elected by the Commercial Engineers were: Henry H. Lynch, president, Hodge Boiler Works; Charles F. Ceilley, vice-president, *National Engineer;* Maj. J. W. Myrick, treasurer, Auto-Force Ventilating System; S. C. Smith, John W. Cannon and John M. Nicholson were chosen as directors.

Ford Offer Turned Down by Senate Committee

Henry Ford's offer for the lease and operation of the government power project at Muscle Shoals has been rejected by the Senate Committee on Agriculture by a vote of 9 to 7. Senator Ladd has been authorized by the committee to draw up a minority report in favor of Ford's proposition. Senator Norris, chairman of the committee, has likewise written a minority report proposing his plan of operation of the plant by a government-controlled corporation. Although both reports will probably reach the Senate before the close of the present session, it is not believed that any action on them will be forthcoming.

The other three proposals for the operation of the Muscle Shoals project, made by the Alabama Power Company, Frederick E. Engstrum, and Charles L. Parsons, were also rejected by the committee, without the formality of a roll call.

Power Papers at Chemical Exposition

At the 1922 National Exposition of Chemical Industries, to be held during the week of September 11-16, at the Grand Central Palace in New York, W. C. Edge, of the Paul B. Huyette Co., will speak on "Safety and Efficiency Appliances for the Boiler Plant;" A. E.

DELEGATES AND GUESTS ASSEMBLED ON THE STEPS OF THE CONVENTION HALL

Campbell, of the Schaeffer & Budenberg Manufacturing Co., on "Instruments for Promoting Efficiency in the Paper Mill;" C. C. Phelps, Uehling Instrument Co., on "The Carbon Dioxide Record of Combustion Efficiency;" Harry Carlson, Sandvik Steel, Inc., on "Steel Belts and Their Application to the Solution of Conveying Problems;" and H. Austin, of Ernest Scott & Co., on "Scott Evaporators as Used in the Paper Mill for Recovering Soda from Spent Liquors."

The principal addresses of the exposition will be given by Herbert Hoover, Secretary of Commerce, and by Wayne B. Wheeler, general counsel for the Anti-Saloon League.

Hydraulic Engineers Combine in South

Complete co-operation among hydro-electric utilities, the federal and state commissions and promoters of water power development in the South was the aim which prompted the recent formation of a permanent body to be known as the Southern Appalachian Water Power Conference. This organization is an outgrowth of a conference held in Asheville, N. C., June 20-22, and attended by the most prominent members of the hydraulic engineering profession in the South, together with representatives of private utilities and government agencies.

At the next meeting of the permanent body, a committee on energy supply will present reports on such subjects as the location of undeveloped water power in the southern Appalachian states, the location of auxiliary steam plants, the making of water-power surveys, the problem of silting etc. Another committee will consider the subject of federal and state legislation relative to water-power development.

A. I. E. E. Planning Vancouver Convention

Following closely upon the annual convention at Niagara Falls, the Pacific Coast Convention of the American Institute of Electrical Engineers will be held Aug. 8-11 at Vancouver, B. C., with headquarters at the Hotel Vancouver.

At the opening session on Tuesday morning, Aug. 8, O. C. Merrill, secretary of the Federal Power Commission, will repeat his paper on "Power Development on the Colorado River and its relation to Irrigation and Flood Control," which was given April 11 before the Washington section of the Society. R. J. C. Wood, engineer with the Southern California Power Co., will give a paper on "The 220-Kv. Transmission of the Southern California Edison Co. and some 220-Kv. Researches." In the evening G. Faccioli, electrical engineer with the G. E. Co., will tell some "Little Stories of Engineering," and there will be a "Pictorial Symposium of Power Plant Comparisons," consisting of a stereopticon talk.

Wednesday morning there will be three papers on insulators, and in the afternoon the following four papers will be given: "Conservation of Human Material;" "Coordination of Professional Engineering and College Training;" "Training to Think *vs.* Gathering Information," and "Engineering Graduates in Business."

Thursday morning there are to be three papers on transmission systems and one on "Exciter Instability." In the afternoon A. H. Babcock, electrical engineer with the Southern Pacific Railway, will give an address on "Mountain Railway Fuel Consumption," and C. E. Skinner, a pioneer in research work and now assistant director of Engineering with the Westinghouse company will speak on "Research."

Friday morning D. W. Isakson, of the Utah Power and Light Co., will speak on "The Development of Telephotography," after which three papers on electrical precipitation will be given. In the afternoon there will be a boat trip to the hydro-electric plant of the British Columbia Electric Railway Co.

Coming Conventions

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Des Moines, Ia., Sept. 11-16. Annual conventions and exhibitions of the State Associations scheduled as follows:

Wisconsin, at Madison, July 26-28; C. Z. Wise, 204 South Carroll St., Madison.

Minnesota, at Minneapolis, Aug. 9-11; C. A. Nelsen, 800 22nd Ave., N. E., Minneapolis.

Iowa, at Des Moines, Sept. 10-11; Abner Davis, Room 16, Waterhouse Block, Cedar Rapids, Iowa.

Universal Craftsmen Council of Engineers; Thomas H. Jones, 33 Linden Ave., Cherrydale, Va. Annual convention and exhibition at Cleveland, Aug. 7-11.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention and exhibition at Minneapolis, Minn., Sept. 11.

Association of Iron and Steel Electrical Engineers, 1007 Empire Bldg., Pittsburgh, Pa. Annual convention and exhibition at Cleveland, Ohio, Sept. 11-16.

New Publications

Analysis of Fuel, Gas, Water and Lubricants.—By S. W. Parr, Professor of Applied Chemistry, University of Illinois, International Chemical Series. Third edition, revised and enlarged. Published by McGraw-Hill Book Co., Inc., New York, 1922. Cloth; 5½ x 8 in. 250 pages; 54 illustrations. Price, $2.50.

This book, although intended primarily as a textbook for students in chemistry and chemical engineering, should be of value to the power-plant engineer, considerable space being devoted to analysis of coal and boiler waters. The book is divided into two parts. Part I is a synopsis of lectures, while part II consists essentially of laboratory directions for the analytical methods there undertaken. The following are the subjects treated: Part I (Lectures): Fuels; Coal; Sampling of Coal; Analysis of Coal; Unit Coal; Calorimetric Measurements, Ultimate Analysis; Classification of Coals; Coal Contracts; Combustion of Coal; Storage; Weathering and Spontaneous Combustion; Coke; Wood; Petroleum, Distillates and Alcohol; Fuel Gas; Flue Gases; Boiler Water; Lubricants. Part II: (Laboratory Methods): Proximate Analysis of Coal; Calorimeter using Sodium Peroxide; Calorimeter using the Oxygen Bomb; Sulphur Determinations; Ultimate Analysis; Fuel Gases Analysis; Analysis of Flue Gases; Analysis of Boiler Waters; Oil Examinations.

Trade Standards In The Pump Industry. Published by the Hydraulic Society; secretary, C. H. Rohrbach, 50 Church St., New York City. Free. A second edition of the Hydraulic Society's pamphlet of standards recommended by its members. Some additional tables and explanatory data and a revised list of society members are given.

Modern Practice in Heat Engines. By Telford Petrie, M. S. C., Assoc. M. Inst. C. E., A. M. I. Mech. E., lecturer at Manchester Municipal College of Technology. Published by Longmans, Green and Co., 55 Fifth Ave., New York City. Cloth; 6 x 8½ in.; 264 pages; illustrations and 2 folding plates. Price, $5.

This book is of greater value to the engineers of this country than its title would indicate. As a description of English and Continental practice it is interesting, but the brief and satisfactory manner in which it deals with the theory of efficiency, design and construction, as well as present-day problems, makes it valuable for those desiring a quick insight into design and application.

Three nearly equal divisions cover boilers, steam engines and turbines, and internal-combustion engines. In each instance, calculations of efficiency and design and construction are handled in a simple and effective manner. Charts appear at intervals, which save time and effort in analysis and determination. The formulas presented are illustrated satisfactorily by working out examples.

The steam-boiler section, 94 pages, describes approximately thirty makes of boilers, from portable and locomotive types to Babcock-Wilcox and Stirling high-pressure units. Classification of various types, evolution, thermal efficiency and performances are reviewed before entering upon detailed description. Principles of steam generation are then covered, which include heat transmission, high gas speeds, economizers, radiation and circulation. Under the chapter devoted to construction are taken up safety, dimensions of various elements, stresses, riveting and illustrated operations.

Section VI deals with Rankine efficiency applied to steam prime

movers, ideal steam consumption, definitions of turbines and engines and descriptions of various types. Principles of turbine design describe efficiency and velocity ratio as applied. The design of a 3,000-kw. impulse turbine is blocked out with calculations in detail, and that for a reaction machine is also described, while problems in turbine design, condensers and auxiliaries are included, as well as engine economy and indicator cards.

Section III treats combustion engines in the same broad and definite manner, leading up to actual rates of fuel consumption with various liquids and gases, and W. J. Walker's chart to a large scale is included. Many European types are discussed and a design problem is briefly illustrated.

Obituary

David D. Faris, manager of the marine department of the Westinghouse company, was fatally stricken with apoplexy in his office at the company's East Pittsburgh works, on Monday, July 10.

Mr. Faris was appointed to the managership of the marine department only ten days before his death, having been promoted from the position of assistant manager in that department. He entered the employ of the Westinghouse company in 1904, after eight years of previous experience in the Bellaire Steel Works of Ohio, the National Tube Co., of Pittsburgh, the National Cash Register Co. and the Pressed Steel Car Co., of Pittsburgh. Until 1915, Mr. Faris served the Westinghouse company in the capacity of sales engineer; from 1915 to 1919 he was assistant manager of the power department, in East Pittsburgh; and in 1919 he entered the marine department, where he remained until his death.

Personals

M. G. Soldini, an electrical engineer of Milan, Italy, has come to this country to devote a year to the study of American central-station practice. He will also make a study of trunk line and suburban railroad electrification.

W. J. Woodcock has been made superintendent of power station, and S. W. Hardin superintendent of overhead construction, of the Olean, Bradford, and Salamanca Railway, Olean, N. Y. C. H. Wales has been appointed electrical engineer.

Earl F. Scott has been nominated for vice-president of the American Society of Mechanical Engineers for 1923. As president and manager of Earl F. Scott & Co., Inc., since 1914, he has designed and supervised the installation of condensers, spray equipment, etc., in numerous power plants. Mr. Scott was graduated from Vanderbilt University in 1903, and after several years in drafting and mechanical designing he was associated with the A. M. Lockett & Co., of New Orleans, and the General Fire Extinguisher Co., at Atlanta.

Clarence G. Hodley, formerly associated with the American Optical Co. in a consulting capacity, has moved out to Minnesota to become superintendent of the Rochester Municipal Electric Plant.

Paul H. Smith, manager of the power division of the Westinghouse Company's Atlanta office, has resigned to take a position with the Brooklyn Edison Co. He has been succeeded by Thomas Fuller, who is now manager of both the power and supply divisions of the Atlanta office.

Business Items

The Conveyors Corporation of America has appointed the Younglove Construction Co., United Bank Bldg., Sioux City, Iowa, as its representative in northwestern Iowa and South Dakota for the sale of American trolley carriers for handling coal.

The Mechanical Appliance Co., of Milwaukee, Wis., has put on the market a new line of Watson A.C. multi-speed motors designed for speeds of 600, 720, 900 and 1,200 r.p.m. The 720-r.p.m. speed has been introduced to avoid a gap between the speeds available.

The J. V. Wallace Co., Inc., Wedgeway Bldg., Schenectady, N. Y., has been organized by J. V. Wallace, who was in charge of the second-hand apparatus department of the General Electric Co. for over twenty years. The new company will buy and sell new and used motors, generators, turbines, engine sets and power machinery.

The C. J. Tagliabue Manufacturing Co. has bought from the Mono Corporation of America the manufacturing and selling rights of its entire line of gas analysis instruments. F. D. Harger, who was general manager of the Mono Corporation, and who has been associated with Mono interests since 1914, has joined the Tagliabue Co. to give advice on combustion problems with reference to Mono installations.

The Mesta Machine Co., Pittsburgh, Pa., has announced the removal of its Chicago office from the McCormick Building to the Peoples Gas Building. C. J. Mesta, second vice president of the company, who has been in charge of the Chicago office for over a year, has returned to the home office in Pittsburgh to take charge of the sales department. A. B. Neumann, mechanical engineer, has been appointed manager of the Chicago office.

The McClave-Brooks Co., has announced that its Pittsburgh office, 1623 Oliver Bldg., is now in charge of George Blair, Jr., who remains district manager of the Philadelphia office. Alfred F. Duemler, formerly sales engineer in the Philadelphia office, will be assistant manager in Pittsburgh. H. L. Hergett, formerly manager of the Pittsburgh office, is now manager of the Syracuse office, as the successor of W. H. Goodrich, who resigned June 30.

Trade Catalogs

Draft and Pressure Gages.—Defender Automatic Regulator Co., St. Louis, Mo. Bulletins 99, 100 and 105, describing a number of different sizes and kinds of draft and pressure gages embodying important improvements over the company's previous line.

Boilers.—E. Keeler Co., Williamsport, Pa. Condensed bulletin, giving information on the company's three types of boilers: longitudinal water tube, cross drum water tube, and horizontal return tubular. A table of principal dimensions of all important sizes is included.

Metal Spraying. — Metals Coating Company of America., Philadelphia, Pa. Well-illustrated pamphlet, describing clearly the process of melting and atomizing the softer commercial metals, and the apparatus used. The following uses of the process are shown: deposition of metals as protective coatings upon surfaces of all kinds; coating for decorative purposes; coating to add weight or to make electrical conduction possible.

Fuel Prices

FUEL OIL

New York—July 20, Port Arthur light oil 22@25 deg. Baumé 4c. per gal.; 30@35 deg., 5c. per gal. f.o.b. Bayonne, N. J.

Chicago—June 28, for 24@26 deg. Baumé, $1.15 per bbl.; 21@36 deg., 3¼c. per gal. in tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—July 20, f.o.b. refinery, Pennsylvania, 36@40 deg., 5c.; Kentucky fuel oil, 24@30 deg., 4c. per gal.; Gas oil, 32@34 deg., 3¼c. per gal.; 36@38 deg., 3¼c.; 38@40 deg., 3¾c. Western, 24@30 deg., $1.35 per bbl.

Philadelphia—July 17, 26@28 deg. Baumé, Oklahoma, $1.05@$1.10 per bbl.; 30@34 deg., Oklahoma (group 3), 2⅞@3¼c. per gal.; 16@20 deg. Seaboard, $1.15@$1.25 per bbl.

Cincinnati—July 13, for 26@30 deg. Baumé, 5c.; Diesel, 32@34 deg., 5¼c. per gal.; distillate 38@46 deg., 5¾c..

Cleveland—July 13, 26@30 deg. Baumé, 4c. per gal.

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	July 10, 1922	July 17, 1922
Pool 1,	New York		
Smokeless,	Columbus	$3.35–3.50	$3.50–4.00
Clearfield,	Boston	3.25–3.75	3.00–3.75
Somerset,	Boston	3.50–3.75	3.25–3.75
Kanawha,	Columbus	3.25–3.50	3.50–3.85
Hocking,	Columbus	3.25–3.50	3.60–3.80
Pittsburgh No. 8	Cleveland	3.90–4.15	4.25–4.50
Franklin, Ill.,	Chicago	.....	.....
Central, Ill..	Chicago	.....	.....
Ind. 4th Vein,	Chicago	.....	.....
West Ky.,	Louisville	4.50–5.25	6.00–6.25
Big Seam,	Birmingham	2.00–2.30	2.00–2.40
S. E. Ky.,	Louisville	3.50–3.85	4.00–4.25

New Plant Construction

PROPOSED WORK

Ark., Stamps—The Louisiana & Arkansas Ry., C. G. Lunday, Vice-Pres., will receive bids until July 31 for locomotive repair shops, including 129 x 286 ft. main building, 60 x 80 ft. blacksmith shop, 68 x 72 ft. power house and 36 x 60 ft. office building; 3 overhead traveling cranes, 90 ton, 65 ft. span, steam heaters with motor and diffusing outlet, 150 hp. boiler either return tubular water tube or Scotch marine type, two 100 kw. D.C. electric generator machines direct connected to four valves, uniflow condensing or non-condensing, turbine condensing, full Diesel or semi Diesel engine, 2,500 lb. steam hammer and condenser boiler feed pump, feed water heater will be installed. Harrington, Howard & Ash, Kansas City, Mo., Consult. Engrs.

Cal., Banning — The Southern Sierra Power Co. is in the market for power house equipment for proposed extension and development, including two power houses. Engineer not announced.

Cal., Los Angeles—A. Bard and O. I. Low, plans to build a 4 story 90 x 145 ft. apartment building, including steam heating system, on 7th and Catalina Sts. Estimated cost $250,000. Russell & Alpaugh, Story Bldg., Archts.

Cal., Mare Island—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will soon receive bids for circulating loop for central power plant here, consisting of two 48 in intake conduits, 6 in. discharge conduit, intake and discharge structures, shafts, sluice gates, operating machinery, etc. Spec. 4684.

Cal., Taft—The Conley School District Trustees will receive bids until Aug. 1 for 2 story school building. Estimated cost $250,000. Trewhitt-Shields, Rowell Bldg., Fresno, Archts.

Cal., Turlock—The Turlock Irrigation District will receive bids until Aug. 3 to construct 28 mi. of 66,000 volt transmission line, to be received as follows: (1) lump sum bids for completed line-contractor to furnish towers and materials, (2) contractor to furnish labor only—district to furnish materials, (3) for materials: about 200 steel towers 170 mi. wire (either copper or steel reinforced aluminum) about 6,000 suspension type insulators, switchboard panel lightning arrestors and oil circuit breaker. R. V. Meikle, Chf. Engr.

Fla., Tallahassee—The West Florida Power Co. plans to build a large hydro electric plant on the Ocklockonee River, here. Estimated cost $1,000,000. Engineer not announced.

Ill., Chicago—The Natl. Kindergarten & Elementary College, 2944 South Michigan Ave., is having plans prepared for a school building opposite the Northwestern University, South Dearborn St. Estimated cost $1,000,000. Warren S. Holmes Co., Tussing Bldg., Lansing, Mich., Archts.

Ill., Chicago—George C. Nimmons & Co., Archts., 122 South Michigan Ave., plans to build 12 story, 50 x 140 ft. office building on 1416 South Wabash Ave. Estimated cost $50,000. Owners name withheld.

Ill., Shelbyville—The city plans election to vote $100,000 bonds for electric light and power plant. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Ind., Evansville—The Evansville Pure Milk Co., plans to build a 60 x 70 ft. power plant, including the installation of refrigerating machinery boiler, etc., on 8th and Walnut Sts. Estimated cost $50,000. Private plans.

Ind., Indianapolis—The Bd. Sanitary Comrs., City Hall, will receive bids until July 31 for sewage disposal plant, including power plant, pump houses, water, steam and air piping, sludge equipment and electric centrifugal pumping units. Estimated cost $300,000. C. H. Hurd, 1405 Merchants Bank, Engr.

Ind., Marion—The Bd. Educ. plans to build a 2 story high school. Estimated cost $300,000. Architect not selected.

Ind., South Bend—The Studebaker Corp., Main and Bronson Sts., plans a 1 story and mezzanine addition to power plant for automobile factory. Estimated cost $100,000. A. Kahn, 1000 Marquette Bldg., Detroit, Mich., Archt. Additional boilers, engine and generators will be installed.

Kan., Topeka—R. S. Planck, c/o The Topeka Daily Capital, is in the market for generator for radio station.

Ky., Horse Cave—W. A. McGuire plans to build a creamery and cold storage plant. Prices wanted on machinery and equipment.

Ky., Owensboro—A. F. Hussander, Archt., 25 North Dearborn St., is preparing plans for 3 story high school, including steam heating system. Estimated cost $250,000. Owners name withheld.

Md., Ilchester—The Thistle Cotton Mills is in the market for boilers, equipment, etc., for power house, now under construction.

Md., Perryville—The U. S. Veterans' Bureau, L. B. Rogers, Acting Dir., Room 1027 Arlington Bldg., Wash., D. C., will receive bids until Sept. 1 for the purchase of 2 complete York 100 ton refrigerating plants in U. S. Veterans' Hospital No. 42, here.

Mich., Menominee—The Wisconsin Public Service Corp., J. P. Pulliam, Secy., 559 Marshall St., Milwaukee, is having plans prepared for additional equipment, in electric power plant, here, including electrical generating unit and transmission line. Mead & Seaston, State St., Madison, Wis., Engrs.

Mich., Sault Ste. Marie—The U. S. Engineering Dept., 337 Federal Bldg., Detroit, received bids for furnishing and installing 6 operating engines for gates of Poe Locks, including motors, controllers, resistances, electric winding drums, etc., from Green Bay Dry Dock Co., Pearl and Ardnt Sts., Green Bay, Wis., $20,410, Elliott Machine Corp., Bush and Severn Sts., Baltimore, Md., $23,469. Millholland Co., 714 15th Ave., Pittsburgh, Pa., $23,600. Noted June 20.

Minn., St. Paul—The State Bd. of Control, D. F. Mullen, Secy., Capitol, is having plans prepared and will soon receive bids for 3 story dairy with wing, including steam heating system, etc., in the College of Agriculture, University of Minnesota. Estimated cost $210,000. C. H. Johnston, 715 Capital Bank Bldg., and J. M. Forsyth, 946 15th Ave. S. E., Minneapolis, Engrs.

Minn., Thief River Falls—The city, A. H. Akre, Clk., is having plans prepared for a water filtration plant, 500,000 gal. capacity. Estimated cost $30,000. L. P. Wolff, 1001 Guardian Life Bldg., St. Paul, Engr.

Miss., Corinth—The city plans election July 29, to vote $100,000 bonds for an electric light and power plant. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Mo., Annapolis—C. T. Dana, 1505 Del Norte Ave., St. Louis, is having preliminary plans prepared for hydro electric plant to develop 2,000 kw. on the Black River. Estimated cost $500,000. Fuller & Beard, Chemical Bldg., St. Louis, Engrs.

Mo., Joplin—The Joplin Globe Publishing Co., O. Taylor, Taylor Radio Co., Wichita, Kan., Purch. Agt., is in the market for generator and other equipment for radio station.

Mo., Kansas City—The Independent Electric Machinery Co., 20th and Central Aves., is in the market for generator and electric motor. (Used.)

Mo., LaValle—The LaValle Light & Power Co. plans to build hydro electric plant and development of water power for manufacturing and lighting purposes. Estimated cost $100,000.

Mo., Sedalia—The City Light & Traction Co. will build an electric light plant. Estimated cost $362,000.

Mo., Sikeston—The city is having plans prepared for a municipal electric light and power plant. Fuller & Beard, Chemical Bldg., St. Louis, Consulting Engrs.

N. Y., Brooklyn—McKay Bros., 495 Hamilton Ave., are in the market for a small diaphragm gas engine pump.

N. Y., Brooklyn—The Metropolitan Material Co., Flushing Ave., is in the market for several 100 hp. boilers. (Type not given.)

N. Y., Brookyn—The H. J. Wheeler Salvage Co., Inc., 224 Bush St., is in the market for 10 x 12 x 18 Duplex plunger pump, with large valve area.

N. Y., Buffalo—The city, A. W. Kreinheder, Comn. Pub. Wks., Municipal Bldg., received bids for furnishing, installing and connecting all steam, exhaust, water suction and discharge piping 8 to 30 in. with valves, etc., to connect 3 high pressure turbine pumping units, ready for operation, at the Col. Ward Pumping station from M. J. Dougherty Co., Phila., Pa., $16,000, J. O'Connor, 98 West Delevan Ave., $16,974, Power Efficiency Corp., White Bldg., $18,250.

N. Y., Buffalo—The Commissioner Public Works received bids for filtration plant Contract No. 1 from Thompson-Starret Co., 49 Wall St., New York, $1,800,480, A Bentley & Sons, 201 Belmont Ave., Toledo, Ohio, $1,801,765, J. Johnson Construction Co., 765 Abbott Road, $2,014,275. Noted Nov. 22, 1921.

N. Y., Buffalo—H. N. Kraft, 26 Summit Ave., plans to build 8 story, 116 x 236 ft. garage and office building on South Elmwood Ave. Estimated cost $400,000.

N. Y., Elmira—The Elmira Water, Light & R.R. Co., F. H. Hill, Gen'l. Mgr., plans to build a gas manufacturing plant for manufacture of artificial gas from oil and steam, including gas holder, capacity 500,000, on Madison Ave. Estimated cost $350,000. Quotations wanted on machinery, cooling apparatus and other equipment.

N. Y., Jamestown — The Jamestown Worsted Mills are having plans prepared by Lockwood, Greene & Co., Engrs., Hanna Bldg., Cleveland, Ohio, for improvements and extensions to plant, including dyehouse, filter plant with pumping equipment, power plant changes consisting of new chimney, condenser and pumps, ash handling apparatus, water storage tanks and heating system throughout old and new buildings; engineers are now receiving bids on filter house and first section of dyehouse.

N. Y., Lockport—The Niagara Sanatorium, R. W. Shelley, Supt., is in the market for 100 hp. Kewanee boiler, or equal quality, for heating plant.

N. Y., New York—G. F. Pelham, 200 West 72d St., is preparing plans for 9 story, 50 x 102 ft. apartment building, including steam heating system, on 17 East 84th St., for the No. 2069 Broadway Corp., c/o Archt. Estimated cost $300,000.

N. Y., New York—The Transit Comn., G. McAneny, Chn., 49 Lafayette St., will receive bids until Aug. 1 for furnishing 2 single motors and motor driven centrifugal pumps and installing with two other pumps, including suction and discharge piping and accessories, in the 14th St. Eastern subway.

N. Y., Rome—The State School for Mental Defectives, C. J. Severance, Pres., will receive bids until Aug. 7 for furnishing engines and motor generators for use in power house of school for lighting purposes.

N. C., Black Creek—The town, G. G. Smith, Clk., will receive bids until July 27 for furnishing and constructing 4 mi. 6,600 volt, 3 phase transmission line, 2 substations and local distribution system, including street lights. H. L. Allen, Engr.

N. C., Lincolnton—Lincolnton Creamery & Ice Co. is having plans prepared and will soon receive bids for the construction of a 2 story, 50 x 100 ft. creamery and ice plant to replace the one destroyed by fire. Estimated cost, including machinery, $20,000. R. P. Blanton, Mgr. Engineer and Architect not selected.

N. C., Marshall—The Bd. of Aldermen will soon award the contract for the construction of dam, reservoir and sterilizing units and furnishing and laying 6 mi. pipe. Estimated cost $36,000. T. A. Cox, Jr., Ashville, Engr.

N. C., Nashville—The city will soon award the contract for 9 miles, 13,000 volt, 3 phase transmission line to Rocky Mount, including 2 terminal substations. Mees & Mees, Charlotte, Engrs. Noted July 4.

N. C., Newton—The city is receiving bids for 500,000 gal. filter plant with coagulation basin, pumping station, small dam and extension of water and sewer lines. Estimated cost $50,000. Mees & Mees, Charlotte, Engrs.

N. C., Wilmington — The Tide Water Power Co., F. A. Matthes, Vice. Pres., plans extending transmission line 53 mi. from here to Warsaw and possibly from Warsaw to Clinton.

Ohio, Akron—The International Lead Refining Co., 151st St. and McCook Ave., East Chicago, Ind., has purchased site and will soon receive bids for 4 buildings on Tallmadge Ave., here. Estimated cost $500,000.

Ohio, Cleveland—F. W. Ball, Archt., Hanna Bldg., will receive bids until July 29 for 1, 3 and 4 story commercial, theatre and apartment, including steam heating system, on East 105 St. and St. Clair Ave. for the Clair Doan Co., c/o J. Laronge, 214 Williamson Bldg. Estimated cost $300,000.

Ohio, Dayton—The Bd. Educ., C. A. Schnidt, Clk., received bids for 3 story Roosevelt high school on the West Side, from Davis-Hunt Construction Co., 907 Schwind Bldg., $1,140,000, Jos. E. Lowes Co., 509 West 2nd St., $1,155,000, Drummond-Miller Co., 4500 Euclid Ave., Cleveland, $1,202,000 heating and ventilating from Van Dyke Heating & Plumbing Co., 1111 Walnut St., Des Moines, Ia., $249,000. Noted July 4.

Ohio, Sidney—The city council, F. Smith, Dir. Service, will receive bids until July 27 for the equipment of a No. 3 well with a deep well pump and motor. B. Coulson, City Engr.

Ohio, Walbridge—The Bd. Trustees, N. Gordon, Clk., will receive bids until Aug. 9 for waterworks system, including pump house, deep well pump, 4, 6 and 8 in. pipe, hydrants, etc. G. Champe, Toledo, Engr.

Ohio, Willoughby—The Andrews Institute for Girls, S. B. Shankland, Secy., is having plans prepared for 2 story educational building. Estimated cost $300,000. F. C. Warner, 767 Hippodrome Annex, Cleveland, Archt.

Okla., Muskogee—The Oklahoma General Power Co., plans to build a power plant, 10,000 hp. initial capacity. Engineer not announced.

Okla., O'Keene—The city will receive bids until Aug. 7 for light and power extensions and well. Estimated cost $45,000. V. V. Long & Co., Oklahoma City, Engr.

Okla., Oklahoma City—The Atchinson, Topeka & Santa Fe R.R., Railway Exchange Bldg., Chicago, Ill., plans to build a Union Station here. Estimated cost $2,100,000. C. F. W. Felt, Chf. Engr.

Ore., Grants Pass—The Irrigation District Bd. of Directors will receive bids until Sept. 15 for 2 units of centrifugal pumps, including 450 hp. motor, 9,000 g.p.m. 154 ft. head and 200 hp. motor, 4,500 g.p.m. 141 ft. head, directly connected and equipped with automatic compensators. Estimated cost $7,000. J. H. Pertig, Engr.

Pa., Erie—The Bd. Educ. will receive bids until Aug. 20 for 2 story 200 x 300 ft. high school on the west side. Estimated cost $425,000. W. W. Myers, Library Bldg., Archt. Noted Mar. 21.

Pa., Erie—Rev. J. M. Gannon, Bishop of Erie, will receive bids until Aug. 10 for orphanage on 6th St. for the St. Joseph's Home for Children. Estimated cost $400,000. J. P. Brenot, Oil City, Archt.

Pa., Phila.—The Benjamin Franklin Hotel Co., c/o H. Trumbauer, Archt., Land Title Bldg., will soon award the contract for 16 story, 196 x 230 ft. hotel, including indirect heating and ventilating systems, refrigerating plant, storage, etc., on 9th and Chestnut Sts. Estimated cost $7,000,000.

Pa., Phila.—The city, C. E. Davis, Dir., Room 696 City Hall, is in the market for 2 motor driven pumps, 20 ft. lift, 15 ft. discharge, 4,200 gal. per minute capacity.

Pa., Stroudsburg—The Nitroloid Corp. of America plans to rebuild celluloid manufacturing factory, which was destroyed by fire. Estimated cost $250,000. Architect not announced.

S. C., Abbeville—The Electric Ice & Fuel Co., P. Link, Secy., is in the market for ice manufacturing machinery and equipment.

W. Va., Huntington—Fesenmier Packing Co. is having preliminary plans prepared for remodeling building into an ice and cold storage plant. Estimated cost, including machinery and equipment, from $125,000 to $150,000. M. L. Fesenmier, Pres. Architect and Engineer not announced.

Wis., Delafield—The Consolidated Material Co., 301 Caswell Blk., Milwaukee, is receiving bids for equipment for gravel pit, consisting of washing plant, 25-30 hp. crusher, pump, screen, bucket and belt conveyors, steam engine or electric motor power. Engineer's name withheld.

Wis., Green Bay—Foeller & Schober, Archts., are receiving bids for 2 boilers, equipment, etc., for boiler room for the I. O. O. F. Lodge, 822 Gragnen St.

Ont., Ford—The Ford Motor Company of Canada, W. R. Campbell, Vice Pres., has purchased site and plans to build a plant for the manufacture of tractors, also extension to automobile factory. Estimated cost $600,000. Private plans.

Ont., London—The London Life Ins. Co., E. E. Reid, Mgr., has purchased site and plans to build a 4 story office building on Dufferin Ave. Estimated cost $500,000. Architect not selected.

Ont., Muncey—The Caradoc Twp., c/o J. Brodie, Clk., is having surveys made for electric light and power distribution system, 11 mi. from Delaware to Melbourne. Estimated cost $33,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

Ont., Whitby—The Provincial Government, Parliament Bldg., Toronto, is having plans prepared for hospital building. About $300,000. Educational Dept., Toronto, Archts.

Mex., Matamoras—The Morrisson-McCall Syndicate, Chemical Bldg., St. Louis, Mo., has acquired the power and light properties and plans to rebuild the system here. Estimated cost will exceed $25,000. Private plans.

CONTRACTS AWARDED

Cal., Palmdale—The Palmdale Irrigation District, Little Rock Irrigation District and the Palmdale Water Co., have awarded the contract for dam here, 145 ft. high, 700 ft. long at top, to Bent Bros., 1714 Eagle St., Los Angeles, about $500,000.

Cal., San Diego—The Cuyamaca Building Co. has awarded the contract for 7 story theatre and office building on B St. to Lange & Bergstrom, Timken Bldg. Estimated cost $1,054,000.

Ill., Chicago—The U. S. Sample Co., 801 South Wells St., has awarded the contract for a 6 story, 125 x 125 ft. printing plant on Jackson Blvd. and Laflin St. to R. F. Wilson & Co., 1851 Elston Ave. Estimated cost $350,000. Steam heating system will be installed. Noted Apr. 4.

Ind., Indianapolis—The James Whitcomb Riley Memorial Hospital Assn., H. McK. Landon, Chn. Bdg. Committee, 904 Hume-Mansur Bldg., has awarded the contract for 3 story, 103 x 321 ft. hospital on West Michigan St. to the State Construction Co., Pythian Bldg., $311,000. Noted May 23, 1921.

Ind., Michigan City—The Sullivan Machinery Co., c/o F. K. Copeland, 122 South Michigan St., Chicago, Ill., has awarded the contract for 1 and 2 story, 50 x 400 ft. and 400 x 550 ft. central heating and power plants, here, to the Witherspoon-Englar Co., 53 West Jackson Block, Chicago, Ill. Estimated cost $1,000,000. Noted July 4.

Ky., Hazard—The city, A. G. Taylor, Clk., has awarded the contract for million gal. filter plant, pumping station, pumps, reservoir, distribution mains and appurtenances as follows: Items 1-2-5-B-5C & 22 to 29 inc. & 6 to 10 incl. to G. B. Howard & Co., 148-B 4th Ave. N, Nashville, Tenn., $29,885, 3-4B-30, Roberts Filter Mfg. Co., Darby, Pa., $13,525, 11, 31, 32-33-34 Mine Service Co., Lothair, Ky., $9,049, 12 to 16 incl., American C. I. Pipe Co., Birmingham, Ala., $8,773.24, 17 to 21 incl. Darling Valve & Mfg. Co., ft. Walnut St., Williamsport, Pa., $831.65. Noted June 20.

Mich., Detroit—The Bd. Educ., 1354 Broadway Ave., has awarded the contract for 2 story school building, including steam heating and mechanical and Plenum system of ventilation, on Brooklyn Ave., to F. H. Goddard, 2130 Franklin St., $295,000. Noted July 18.

Mich., Detroit—The Northwestern Bldg. Corp., 7380 Grand River Ave., has awarded the contract for 2 story theatre and office building, including steam heating boilers and equipment, to the John Finn & Sons Co., 708 Amsterdam Ave. Estimated cost about $2,000,000.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, has awarded the contract for a New Utrecht high school on 79th St. and 16th Ave. to the Werner Disken Co., 50 Court St., $1,336,897. Noted May 23.

N. Y., Buffalo—The Bd. Educ., 1401 Telephone Bldg., has awarded the contract for P. S. No. 68 on Case St., to W. W. Wade, 816 Ashland Ave., $299,137, heating, Power Efficiency Corp., White Bldg., $64,990.

N. Y., Elmira—The St. Joseph's Hospital, 555 Market St., has awarded the contract for hospital building to the P. A. Zimmerman Co., 18 East 41st St., New York, $211,000.

N. Y., Green Island—The Ford Motor Co., B. R. Brown, Constr. Dept., Highland Park, Mich., has awarded the contract for a 1 story automobile factory, with craneway and traveling cranes, including steam heating system, to the Fred T. Ley Co., 495 Main St., Springfield, Mass. Miscellaneous equipment for assembling motors to be installed.

N. Y., Riverhead—The Bd. Educ. has awarded the contract for high school to Johnson & Miller, Yonkers. Estimated cost $250,000. Noted Feb. 21.

N. C., Ashville—F. Byram has awarded the contract for the construction of a 250 room hotel, to the Foundation Co., 120 Liberty St., New York. Estimated cost $1,000,000. Noted June 22.

N. C., Charlotte—The Citizens Hotel Co., has awarded the contract for 12 story, 100 x 193 ft. hotel to the J. A. Jones Contracting Co., Realty Bldg., $713,480. Contract for heating and lighting systems will be awarded about Aug. 1. Noted June 27.

Ohio, Cleveland—The Bd. Educ., F. G. Hogan, Dir., East 6th St. and Rockwell Ave., has awarded the contract for 3 story addition to high school on West 93d St. and Willard Ave., to the Drummond-Miller Co., 4500 Euclid Ave., $652,000, heating and ventilating systems to Warcleu & Leese, Prospect Ave., $130,697. Noted July 13.

Ohio, Cleveland—The Studebaker Corporation of America, E. J. Murane, Sales Dir., 2020 Euclid Ave., has awarded the contract for a 3 story, 140 x 148 ft. service building on East 25th St. to S. W. Emerson, 1836 Euclid Ave. Estimated cost $250,000. Noted July 4.

Okla., Fairlands—The city has awarded the contract for water tower tank, distributing system, etc., to Gains Bros., $22,800, electrical work to the Peabody Elec. Co., Muskogee, $12,830. Noted June 20.

Pa., McKeesport—Bd. of Educ. has awarded the contract for the construction of a 2 story, 90 x 275 ft. high school to E. H. Canon, McKeesport. Estimated cost $300,000. Noted Nov. 29, 1921.

Pa., Phila.—S. Lavenson, 237 North 6th St., has awarded the contract for 8 story, 80 x 102 ft. office building on 8th and East Appletree St., to the Kober Construction Co., 34 South 17th St. Estimated cost $500,000. Indirect steam heating system will be installed.

Tenn., Nashville—Caldwell & Co., 205 Union St., has awarded the contract for 8 story bank and office building on 4th and Union Sts., to the Foster & Creighton Co., 4th and 1st Natl. Bank Bldg., $350,000. Steam heating system will be installed. Noted July 4.

Wis., Eau Caire—The Chippewa Valley Produce Co., 220 South Water St., has awarded the contract for 2 story, 70 x 125 ft. cold storage warehouse, including conveyors and cooling apparatus, to A. Larson Co., 418½ South Barston St. Estimated cost $65,000. Noted June 27.

Wis., Madison—The city, H. C. Buser, Clk., has awarded the contract for heavy duty air compressor for pumping station to The Nordburg Mfg. Co., Chicago and Oklahoma Sts., Milwaukee, $23,350. Noted June 27.

Wis., Milwaukee—The Claybourn Process Corp., Menasha, has awarded the contract for a 30 x 80 ft. heat treating and boiler room and 100 x 180 ft. administration building on Humboldt Ave., to P. Riesen's Sons, 1018 Humboldt Ave. Noted June 13.

Wis., Union Grove—The State Bd. Control, M. J. Tappins, Secy., Madison has awarded the contract for 2 Uniflow engines and generators to the American Iron Works, Oswego, N. Y., $19,400, 400 motor driven compressors to the Ingersoll Rand Co., 342 South Dearborn St., Chicago, Ill., $5,370, marine boilers and furnaces, Freeman Mfg. Co., Racine, $14,350.